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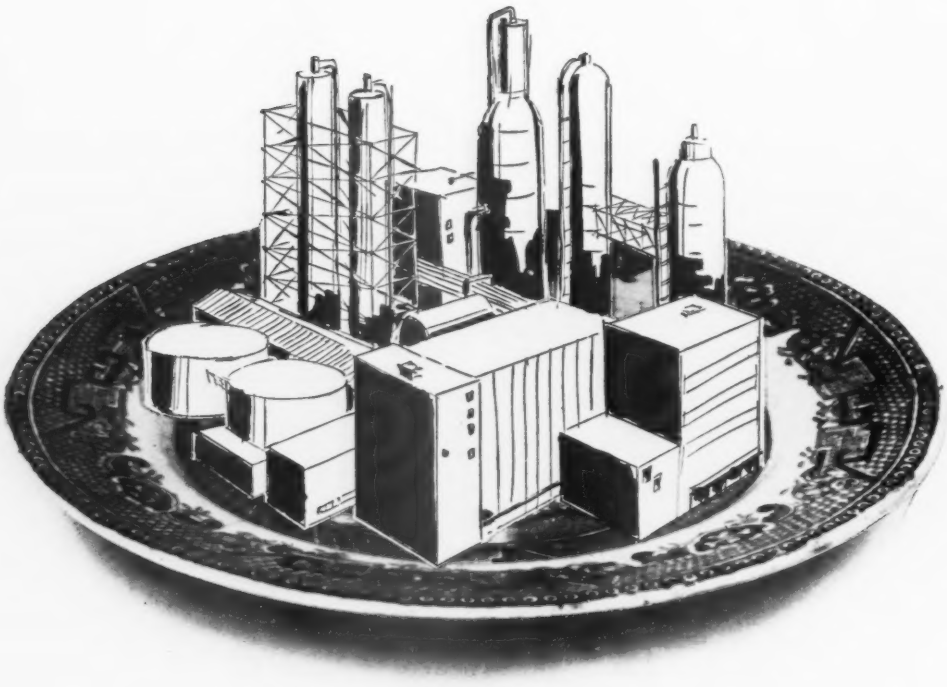

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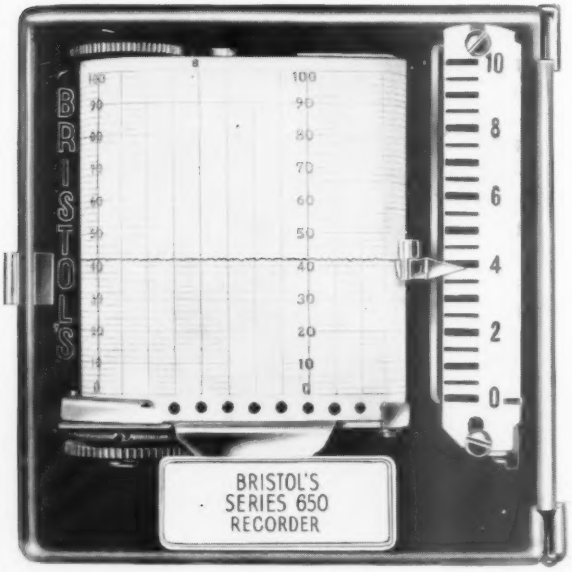

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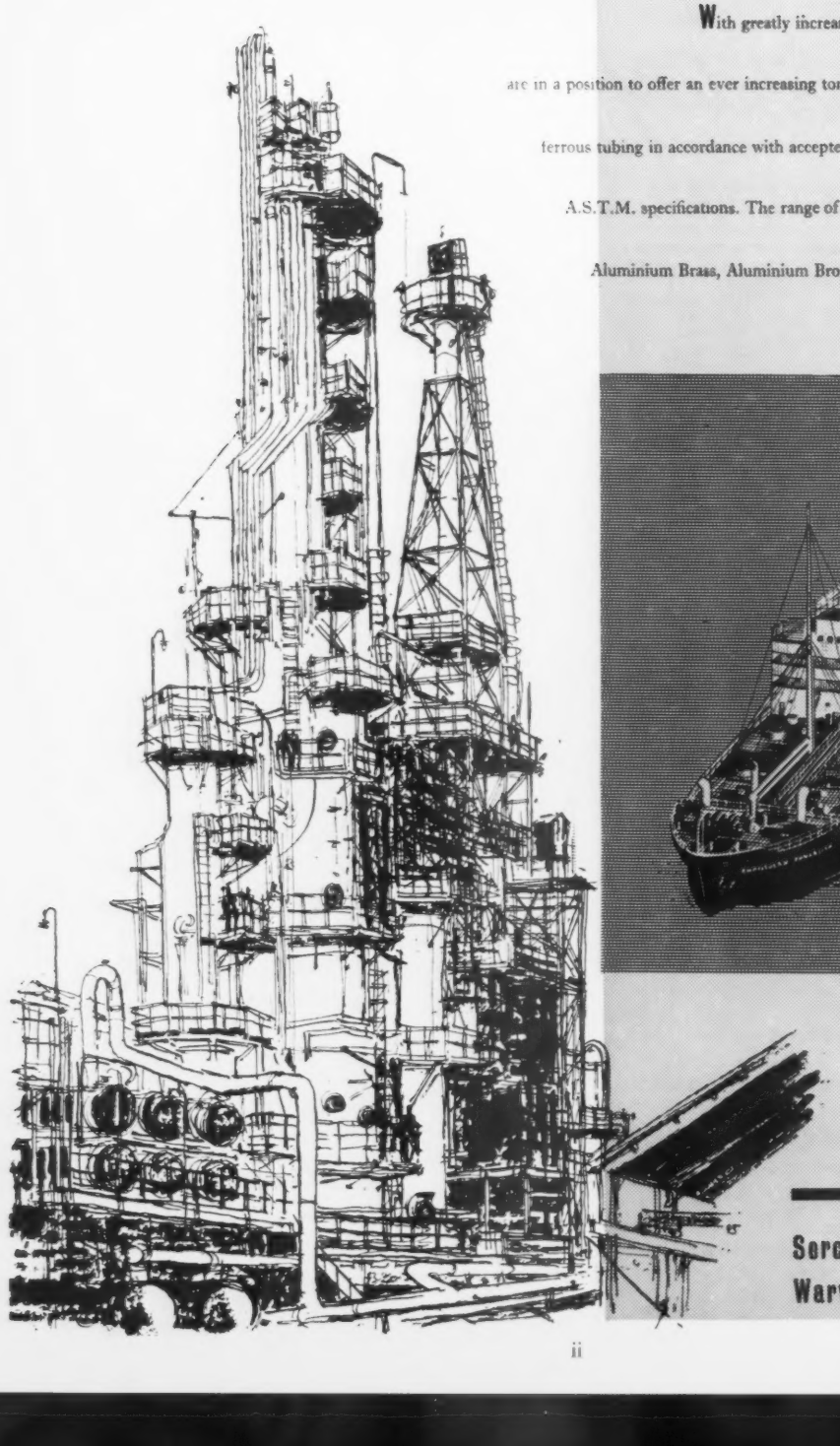

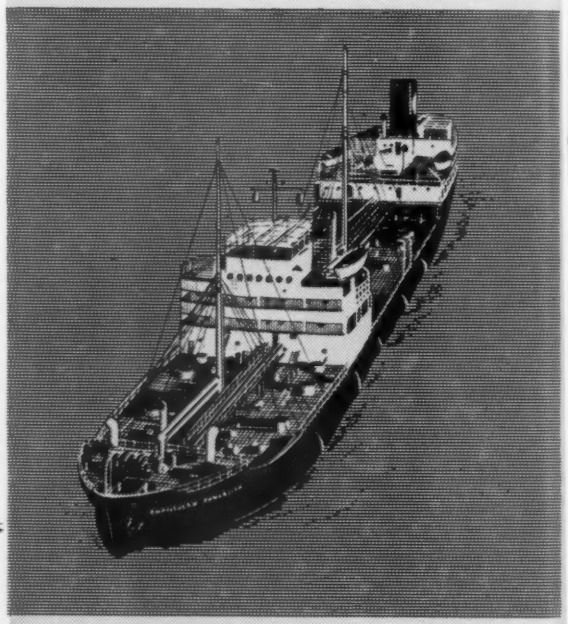

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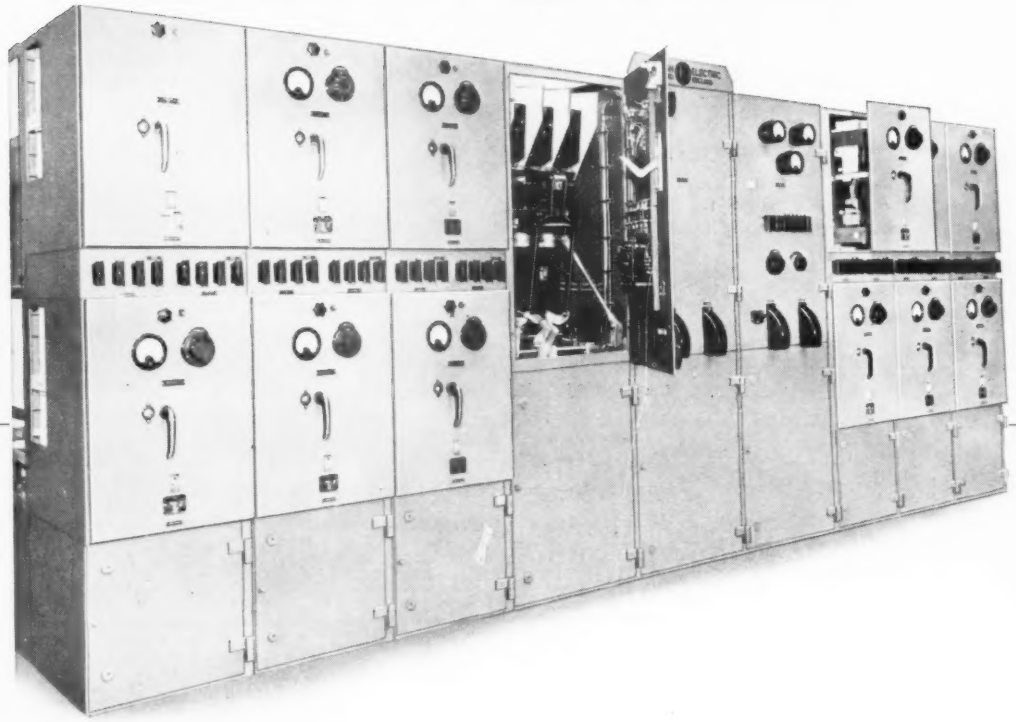

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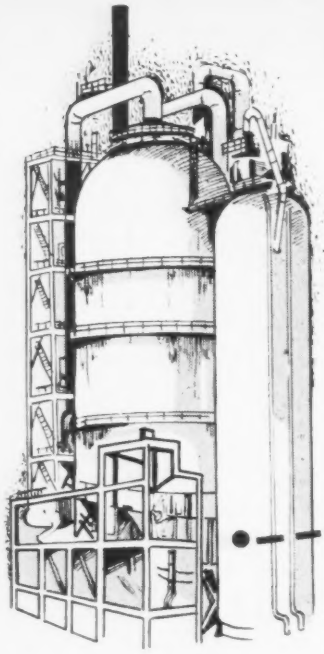

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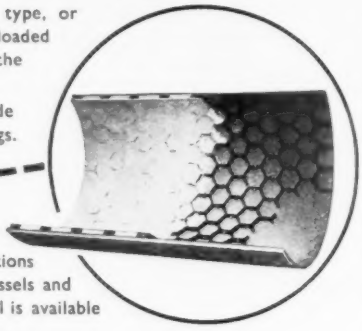

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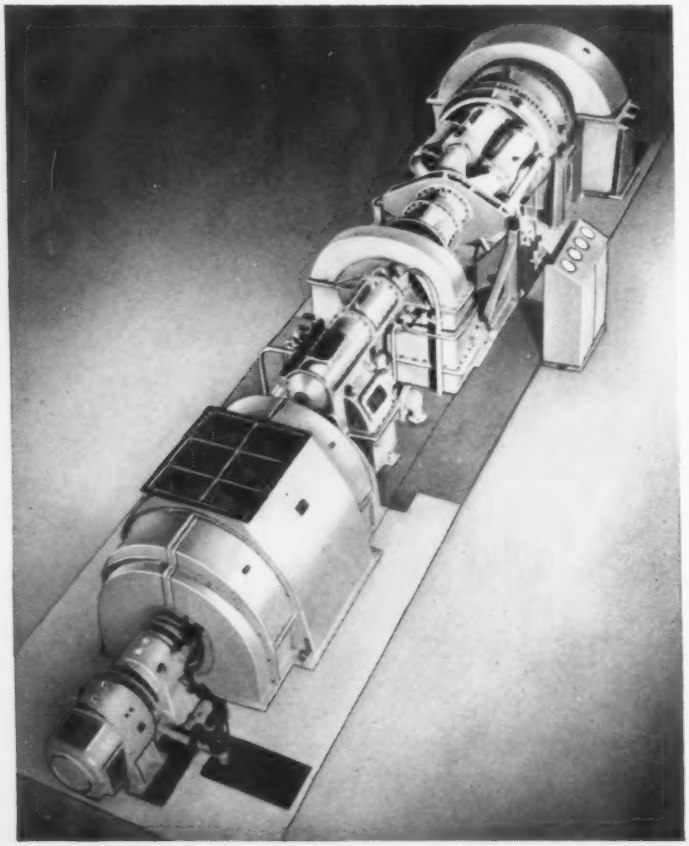

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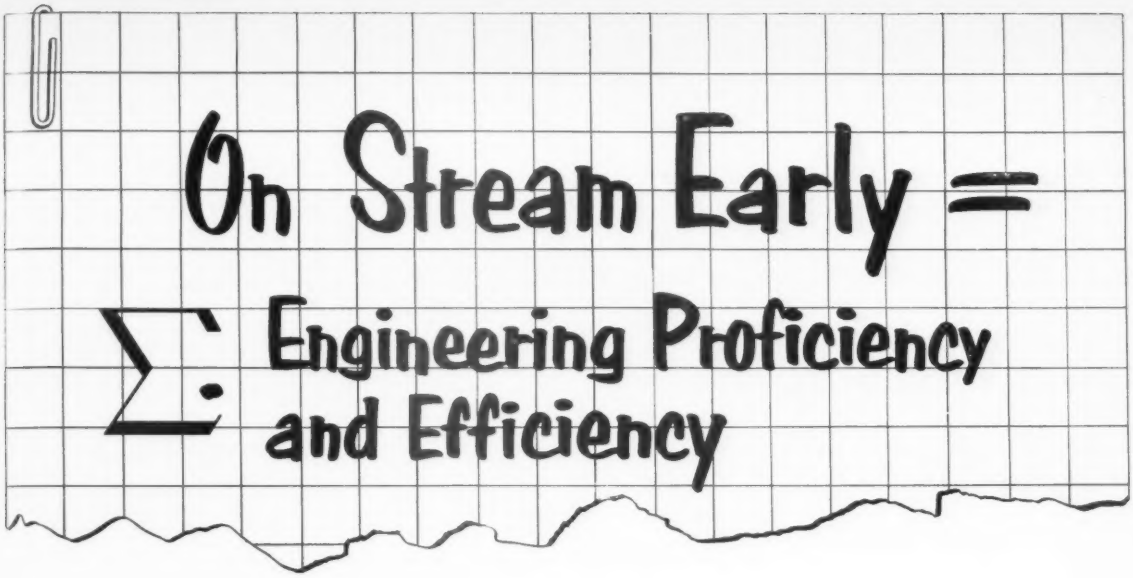

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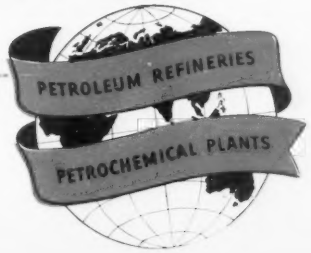

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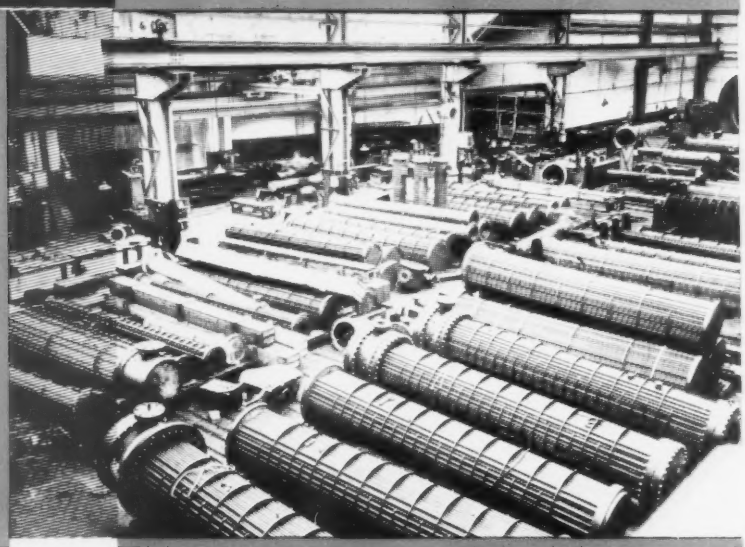

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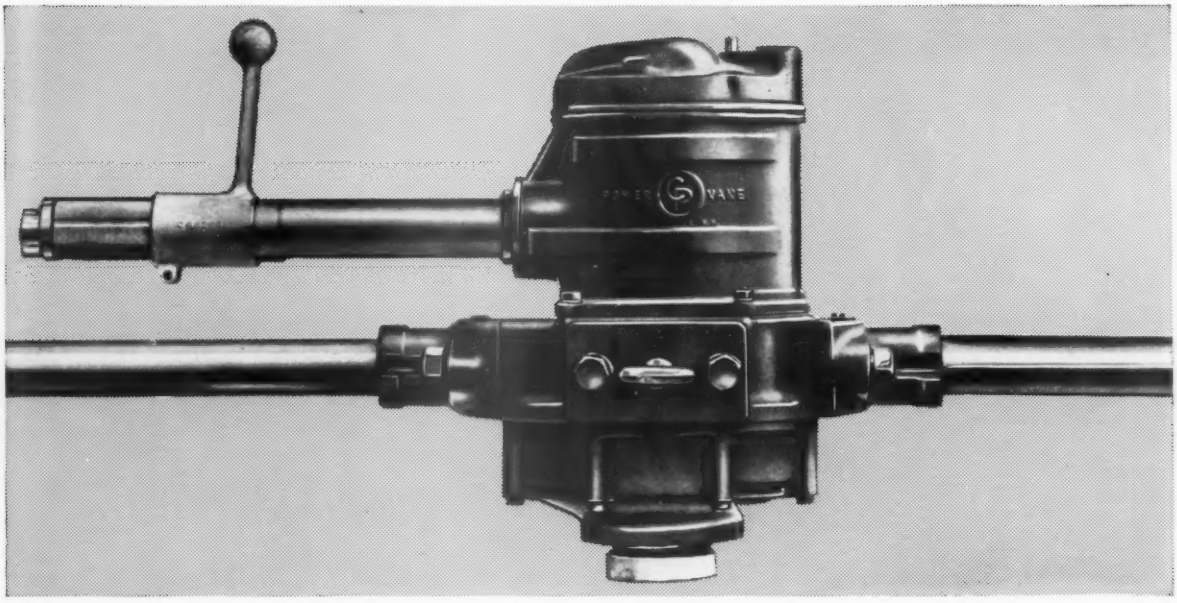

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Problems of Retaining Refinery Production in Balance with Demand

By **B. F. NEWTON**

This paper was read to the Economics and Operations Group of the Institute on 6 March 1956. Mr Newton is on the staff of the Esso Petroleum Co Ltd, Fawley.

Since the war the pattern of refinery production in the U.K. has largely been controlled by the outlets available for gasoline sales. In this connexion it may be interesting to compare the pattern of demand in the U.K. with that in the U.S.A., and to show the influence of this demand pattern on refinery operations. These are shown in Figs 1 and 2 as percentages of requirements on the oil industry, and whilst the demand in both countries shows a striking rate of increase, there are significant differences in the pattern of requirements.

In the U.K. the increase in demand is unevenly distributed between the products, and whilst there is a sign of a flattening-out in gasoline demand, the requirements for middle distillates and fuel oils increase very rapidly. Since Middle East crudes contain a fairly high proportion of gasoline, approximately 25 per cent, any limit to the amount of gasoline that can be sold will inevitably mean, as it has done in the past, that crude runs will be limited sometimes below refinery distillation capacity, or that naphtha has to be burnt as fuel oil.

This problem has been rendered more acute by two main factors. First, the high level of taxation on motor gasoline has encouraged the trend towards diesel engines, and the private motorist is tending more and more to use medium horse-power cars, with a relatively low gasoline consumption per unit. Secondly, the natural demand for middle distillates has been greater than the demand for gasoline in terms of the relative proportions of gasoline and middle distillates indigenously available in crude oil.

Thus, the pattern of requirements placed on a U.K. refiner is in striking contrast to that pertaining in the U.S.A., where the picture is essentially to maximize gasoline production

Fig 1. United Kingdom pattern of demand —% of total.

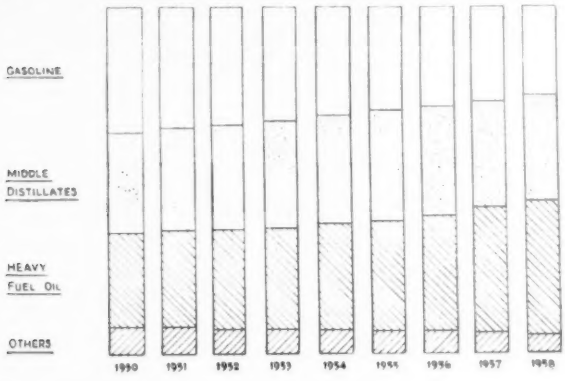
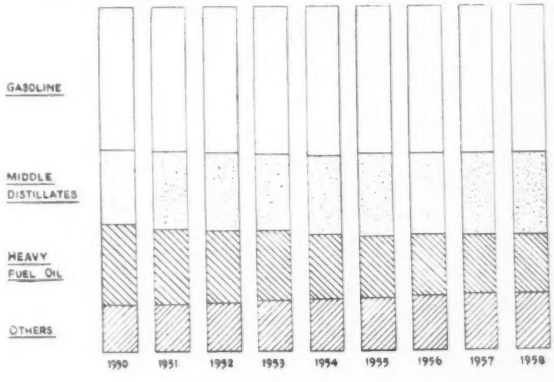


Fig 2. United States pattern of demand —% of total.



and minimize fuel oil, which is the lowest priced product. In the U.K., minimum gasoline production is often the necessary aim, and both present and anticipated future demands for middle distillates are high, with a very definite customer preference for virgin stocks, *i.e.* distillates cut straight from crude oil and excluding cracked oils. The implications of this demand pattern on U.K. refiners can best be considered by seeing how it is possible to convert crude oil into a pattern of products which will meet the market demand as closely as possible.

Pattern of Demand

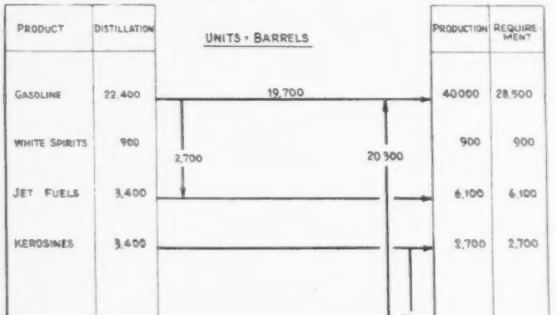
For many years, some U.K. refiners have solved both the problem of increasing gasoline requirements and obtaining better quality gasoline by installing catalytic cracking processes which have converted high boiling gas oils into high octane gasoline. In the present situation of the decreasing percentage gasoline demand it is quite obvious that installing further catalytic cracking capacity would merely accentuate the problem.

In the past year or so, an attempt has been made to solve and correct the situation by the installation of catalytic reforming processes such as Hydroforming and Platforming which produce high octane blend stock from virgin naphtha feed.

Whereas the conventional catalytic cracking process converts some potentially saleable middle distillate into gasoline, the catalytic reforming process converts low octane gasoline into high octane material with some loss in yield. Thus, for any given gasoline market requirement it is therefore possible to run more crude at a refinery which is equipped with a catalytic reforming process than at one which has catalytic cracking alone.

Quite apart from the trend towards catalytic reforming which is being dictated by the demand pattern of gasoline and middle distillates, there has been growing for some time in the U.K. a demand for higher octane gasoline which can in fact be met only by some form of catalytic reformer. This has been evidenced by the growing public demand for the premium grades of petrol, sales of which have far exceeded the original expectations, and by the trend towards very high efficiency, small engine design, and higher compression ratios.

Fig 3. *Meeting* 1956 *product pattern catalytic cracking only* 87 *octane number.*



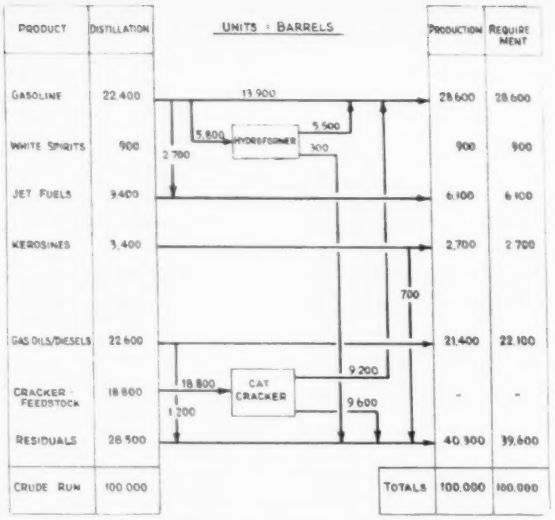


Fig 4. *Meeting* 1956 *product pattern catalytic cracking and catalytic reforming* 87 *octane number.*

Fig 3 outlines a processing scheme of a refinery equipped with catalytic cracking only. The scheme supposes that the refinery is operating to meet prime fuel product requirements of white spirit, turbo jet, and kerosine, and the net result is that there is a large excess of gasoline and fuel oil produced, whilst all the potentially saleable gas oil and diesel fuel production has to be fed to the cat cracker in order to meet the octane requirements of the gasoline pool, and there are no gas oils available for sale as such. In practice of course, no refiner could operate to produce this surplus of gasoline without an assured market outlet, and inevitably, crude runs would have to be cut, thus accentuating the shortage of middle distillates and producing a deficiency of fuel oil.

There are, of course, several things which the refiner can do to alleviate this somewhat dark picture, *e.g.* the volume of virgin naphtha produced can be kept to a minimum by carefully controlled fractionation, by careful stripping of middle distillates, and by operating at minimum flash points on the middle distillate cuts. Also, he could endeavour to increase the efficiency of the cat cracking operation in order to produce maximum gasoline from minimum cat cracking feed, thus leaving available for sale as much as possible of the middle distillates produced in the crude operation.

However, even with these alleviations the picture would be extremely bleak and would be worsened still further by the demand for higher octane gasolines which would occasion increased cat cracking, and, if the total volume of gasoline is to remain unchanged, reduced crude runs.

Whereas cat cracking involves the production of more gasoline as the octane demand increases, catalytic reforming, by virtue of using a virgin naphtha feed stock, produces less gasoline as the octane demand increases. It is clear therefore, that a combination of both processes will provide a wide flexibility in adjusting the ratio of gasoline to middle distillate production, and at the same time maintain crude runs.

Fig 4 shows in a similar manner to Fig 3 a processing scheme which includes both catalytic cracking and catalytic reforming, and that production and demand can readily be brought into balance. The use of virgin naphtha as feed stock for the cat reforming process, reduces the volume of low octane virgin naphtha which has to be accommodated in the gasoline pool and at the same time permits middle distillates which would otherwise have been cat cracked, to be sold as such.

Fig 5 shows the way in which a significant increase in the gas oil–diesel requirements can be accommodated by changing the cat reforming operations whilst at the same time meeting a decreased gasoline requirement.

Fig 6 considers the implications of a 5 octane number increase in the gasoline pool, based on the same demand pattern as used in Fig 5. In order to meet the increased octane number, catalytic reforming throughput has to be significantly increased, and the cat cracking throughput considerably reduced.

It seems abundantly clear that catalytic reformer processes will be of increasing importance to the U.K. refiner in the next few years.

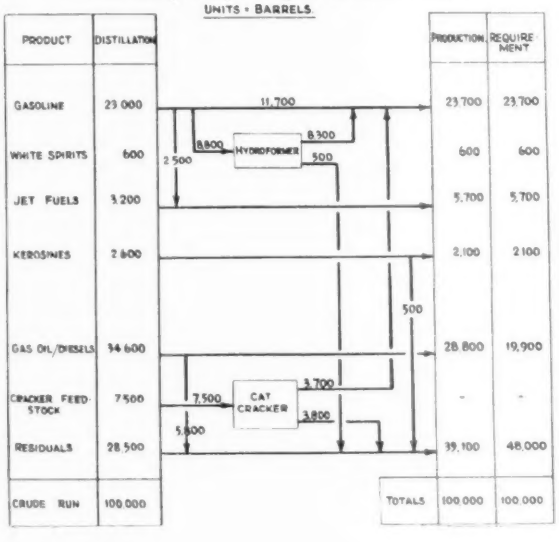
Energy Demand

Perhaps the biggest problem that the refiner has to contemplate in the future is the growing demand for energy which springs from the desire to increase the standard of living by increasing productivity. This increased demand for energy is unlikely in the U.K. to be met from increased coal production, and the contribution of atomic energy is unlikely to be greater than 10 per cent of the total energy demand in the next 10 years or so.

Consequently, the energy demand will have to be met very largely from the oil industry, and some idea of the significance of this demand may be seen from the estimates of inland gasoline and fuel oil requirements given in the following table:—

	1954	1964
	per cent	*per cent*
Gasoline	36	25
Total fuels	21	47

Fig 5. *Meeting* 1960 *product pattern—*1 *catalytic cracking and catalytic reforming* 87 *octane number.*



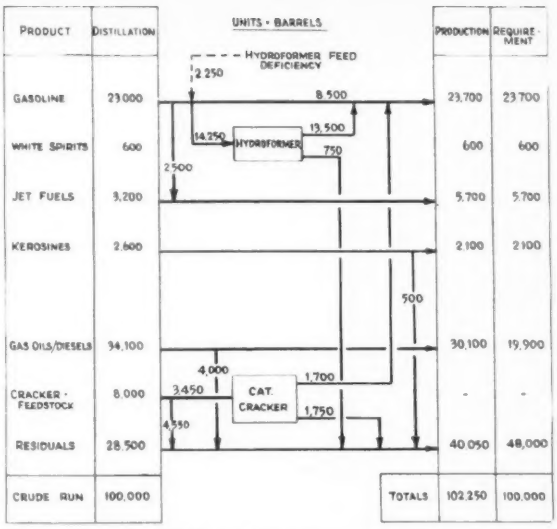


Fig 6. *Meeting* 1960 *product pattern—*11 *catalytic cracking and catalytic reforming* 92 *octane number.*

This feature of increasing fuel oil demand is shown in Fig 6, where the deficiency of fuel oil was counterbalanced to some extent by the surplus of middle distillates.

Since it appears it would be uneconomic to degrade these middle distillates to fuel oil merely to make up the volume deficiency, it may reasonably be inferred that there will be a growing demand for heavy crude oils containing a high percentage of fuel and low naphtha content.

To summarize, therefore, the question of retaining refinery production in balance with market demand is a very real problem indeed for the refiner, and a solution is essential if the U.K. is to achieve the doubling of the standard of living forecast by the previous Chancellor of the Exchequer.

DISCUSSION

The problem of retaining refinery production in balance with requirements without considering the effect of product quality was raised by **W. A. Partridge,** who said that the author had ignored the very real effect which product quality considerations can have on the refinery picture.

Continuing, Mr Partridge said that whilst the need for increased catalytic reforming could be readily foreseen in the U.K., its increasing use would raise kindred problems regarding the volatility of gasolines from the point of view that the light virgin naphtha which is not fed to a catalytic reformer would have to be incorporated in the gasoline pool. Thus a refinery with only crude distillation and Hydroforming units would find it very difficult to produce an on-grade volatility gasoline.

A similar problem would arise in that whilst Hydroforming the heavier virgin naphtha it was also desirable to have some means of improving octane ratings of the light distillates—the light gasoline fractions of one's crude. In addition to the problem which Mr Newton has posed there will very soon arise the snag of having an excess of light gasoline from Middle East crudes, for which, as far as is known, there is no real process in sight for improving the octane number. Also, of course, if one could improve the octane number, one would reduce the yield, thus again strengthening the

thesis that one should start by looking at quality and add to it one's quantity problem afterwards.

In regard to fuel oils, again the quality of Middle East crudes was of importance, for there are some heavy Middle Eastern crudes which have high yields of fuel oil. But the problem was to persuade the user to accept higher carbon residues and relatively higher sulphur contents.

B. F. Newton, agreeing with Mr Partridge, said that to consider volume without any reference to quality was only part of the answer to the problem.

On the question of volatility of gasolines, Mr Newton maintained that he was generally right in asserting that it is possible to achieve satisfactory volatility, providing one had both cat cracking and Hydroforming units. He agreed entirely that if a situation arose where one had nothing but distillation and catalytic reforming, then one would most probably have an acute volatility problem, because there is no way of sinking the light virgin naphtha in gasoline. Regarding the octane number of light naphtha, although Mr Newton had heard of some processes which will up-grade light virgin naphtha, he had not heard of any economic treatment.

He thought there was some alleviation for that particular problem, *i.e.* it was possible to depentanize light virgin naphtha, or even cat naphthas, in order to get a selective stream for volatility blending.

W. S. Ault thought that engine developments in both the gasoline and the diesel field may have a substantial effect on the balance of quality and quantity. He had in mind the possible general adoption of petrol injection in gasoline engines, thereby making low volatility of rather less importance, so long as the octane number was all right.

Mr Gresham referred to the competition arising between feedstock for the catalytic reforming process and the increasing demand for the gasoline type of jet fuel. He enquired whether that was going to give rise to problems in the future, as he felt there was probably some conflict of interest there.

In reply **B. F. Newton** thought probably not, because, generally, the point had not been reached where the volumes are high enough to conflict. Ultimately, when the demand for gasoline was sufficiently high such a conflict must inevitably arise.

Mr Newton thought that there was, however, possibly a conflict between the requirements for high-flash jet fuel and kerosines, which tended to be much in the same range.

W. A. Partridge said it appeared that in the 150°-200° F boiling range one had a material which could be routed either into middle distillate or motor gasoline, as may be desired. Should this material be required for cat reforming also, one could very easily run into a situation where the key to operating a refinery becomes the volume of 150°-200° F naphtha obtained from the crude.

B. F. Newton said it was correct to base one's assumption on a growing octane demand. At the present time, there was a need for more cat reforming of essentially 150° to, say, 300° F end-point virgin naphtha, and Mr Partridge was correct in saying that this type of material had a possible outlet in middle distillates, although at present, middle distillates, apart from turbo-jets, tended to be cut above 300° F rather than below it. Developments in that field, of course, really changed an over-all surplus of virgin naphtha which is in the 0°-360° F.V.T. range to an over-all surplus of 0°-200° F.V.T. naphtha. But it was still the same basic problem—one merely moved the middle distillates down a bit.

In regard to the economics of the problem of refinery balance, **Mr Goseman** asked if it was possible that in view of the future demand for energy, to which Mr Newton referred, refineries in the U.K. would not be able to produce fuel oils in the quantities that would be needed. Taking this a stage further, he asked Mr Newton to indicate whether there was any prospect of regarding Europe as a sphere, in which supply and demand must equate. Would refineries in, for example, Norway and France, feed the British market?

Before **Mr Newton** replied he asked if Mr Goseman would first say in what way he thought that would solve the problem of meeting a higher fuel oil demand. He also asked if Mr Goseman was suggesting that the Scandinavian countries could not have a high fuel oil demand.

Mr Goseman said he was merely anticipating that possibly the growth in U.K. demand would precede the higher demand in, for example, the Scandinavian countries, and by widening the zone of supply and demand, some relief might be given to refinery balance.

B. F. Newton said that, on the whole, he thought not. If one ignored Russian production, and considered that of Free Europe, he did not think that there was any sign of a fuel oil surplus in any of the European and Scandinavian countries. He thought that the problem, although it might happen first in the U.K., was certainly going to be felt in France and Germany, and although he agreed in principle that the economic equation of the whole area was probably a good ideal, he did not think it was going to help this problem very much.

M. E. Hubbard said that the U.K. had the highest percentage of gasoline demand of any of the countries in Western Europe and that all the others had an even more acute fuel oil problem than the U.K.

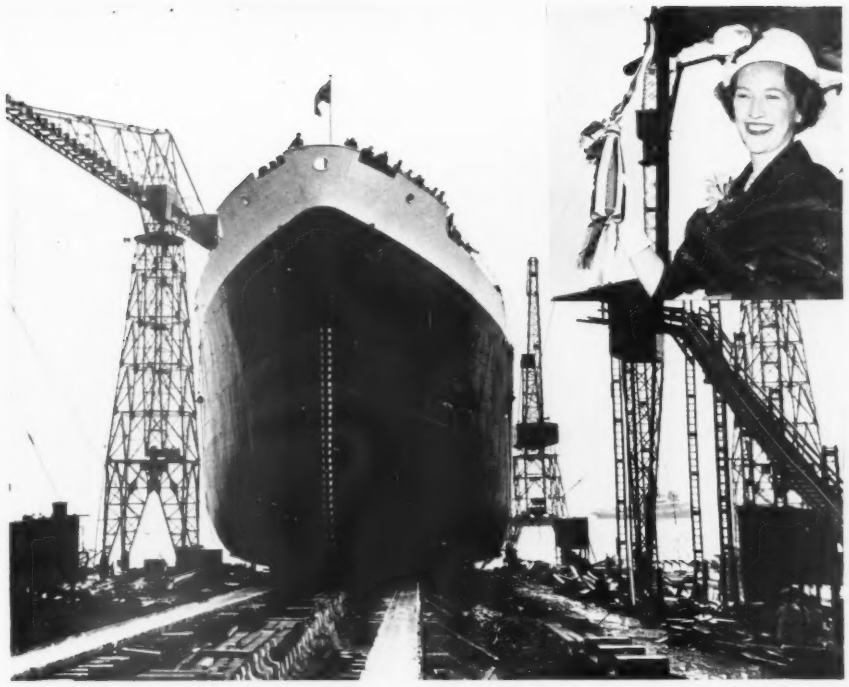
C. I. Kelly said he would like to enquire, first, whether Mr Newton could see any alleviation of his problem in refineries burning more gas and less fuel oil.

Secondly, he wondered whether the problem would be eased by the projected increases in the primary distillation capacity at crude source, since he recalled that, before the war, when the problem was reversed and gasoline demand was greater than fuel oil, crude was topped and fuel oil run back to the oil wells.

Thirdly, he referred to the Kent oil refinery situation, where a link had been established with a gas company, with the idea of increasing the output of both gas and oil. Does that offer a partial solution to the problem inasmuch as an excess of a particular product could be converted into gas for use in the gas stove?

Mr Newton thought that as regards burning more gas, nearly every refiner would automatically burn as much gas as he possibly could because if he did not do so it would be wasted.

The facilities going up at Kuwait and Venezuela were a first attempt to solve this problem of a higher demand for fuel oil than there had been in the past. As regards pumping virgin naphtha back to formation, this had been done in the past, and might have to be done even more in the future, providing it was economically justifiable.



Launching of s.t.s. "Hydatina"
The 18,000-*ton dw "Hydatina" was launched for Shell Tankers Ltd on* 23 *August from the yard of Messrs Lithgows Ltd, Port Glasgow. The naming and launching ceremony was performed by The Viscountess Bearsted* (shown inset *about to christen the tanker*), *wife of The Viscount Bearsted, T.D.* (*Chairman Messrs M. Samuel and Co Ltd*).

A Shell photograph

DISCUSSION [*continued from p.* 260].

Mr Newton also thought that the gas-from-oil project was an extremely sound thing and he believed the contract was written so that whatever was surplus in the refinery would be used.

M. E. Hubbard said he understood that one refinery in the U.K. was equipped with a digital computer, and he enquired to what extent would this be of direct assistance in the solution of day-to-day problems.

In reply, **B. F. Newton** said the primary justification was in saving technical manpower. At the present time, the computer had been used successfully for certain routine jobs, such as mass spectrometer calculations, meter constants, and some catalytic cracking correlations, and some of these were now being turned out on a routine basis. It was hoped in the near future to get refinery running plans on to the computer for the prime purpose of producing as many variations on the theme as possible. They were the chief kinds of application which could be foreseen at the present time but there was also a wide use for the computer for accounting purposes but that was rather outside the scope of this discussion.

P. M. de Veulle said that the question of how this great deficiency of coal was, in fact, going to be made good by the oil industry was one which must have exercised the minds of many people in the industry and indeed, throughout Western Europe. Those who were not refinery people had a great faith in the ability of the refiner to produce whatever was necessary. It had always happened in the past, and it was hoped that it would also be done in the future.

ASSAM OIL DEVELOPMENTS

Digboi Batori, house journal of the Assam Oil Co, reports that negotiations are in hand between the Government of India and the Burmah Oil Co Ltd for the development of the new oil areas of Assam. The proposals under consideration included the formation of two new rupee companies, one to explore for and produce oil in Nahorkatiya, Hugrijan, and Moran, and the other to undertake refining. The Government would have a third share in the exploration company and a substantial majority holding in the refining company.

A major point to be decided is the transport of oil from field to refinery, and this affects also the location of the refinery.

It is stated that the Nahorkatiya area is capable of producing at the rate of one million tons a year for at least 20 years. Recent intensive work by the Assam Oil Co had indicated a possible yield of two million tons per year.

★ ★ ★

APPLIED RADIATION AND ISOTOPES

In an editorial in the first number (July 1956) of this new publication, Sir John Cockcroft refers to the tremendous strides in industrial research and process control made in the last decade through the use of radioactive methods. Isotope methods of potentially wide application have been published in scattered journals and the results, rather than the methods, have been emphasized. It is the intention of *Applied Radiation and Isotopes*, which is published by Pergamon Press Ltd, 4 and 5 Fitzroy Square, London W.1 at £6 per volume (£3 10s. to individuals for private use), to provide a forum for publication and discussions of these techniques and to promote international co-operation.

Aramco 1955 Operations

In reporting to the Saudi Arabian Government on its operations during 1955 the Arabian American Oil Company (Aramco) records an average daily production of 965,041 barrels, an increase of 12,041 over the figure for the previous year. For the last three months of the year the average was over one million barrels and the November 1955 production was the highest ever at 1,041,098 barrels. Statistical details extracted from the report, which is profusely illustrated, are given in Table I.

The reduction in the quantity of crude oil processed at the Ras Tanura refinery in 1955 was due to a decline in the demand for finished products. The completion in 1955 of the first fluid hydroformer to be built in the Middle East at a cost of $13 million will enable Ras Tanura to meet demands for higher quality gasoline. Other major improvements were carried out, including preliminary work for a 15,000-b.d. diesel desulphurization unit.

At the end of the year 155 wells were in production. It is planned to bring the Safaniya field into production in 1957, and the proposed water injection programme for the Abqaiq reservoir is scheduled to start in 1956.

Natural gas from the Dammam reservoir, together with a portion of that from the Qatif reservoir, were used in the Dhahran area. Available gas in the Abqaiq area was returned to the producing zone at the rate of approximately 150 million cubic feet daily.

During 1955 two new oil wells were drilled in the Safaniya field and one in Ghawar, Safaniya 17 being a deep test and reaching 13,297 feet. The drilling programme extended the proved areas in Safaniya and Ghawar and Aramco's reserves at the year end were estimated at 30·35 billion barrels.

Exploration

Work was continued to determine oil prospects of the concession areas, geological and geophysical methods being employed. At the end of 1955, three structure-drilling, three seismic, one gravity-magnetic, and one surface-mapping parties were operating.

Gravity-magnetic parties in the central and eastern Rub'al-Khali met most difficult sand conditions and it was impracticable to move camp trailers to desired locations. Small temporary camps were used to make the survey.

In the western and southwestern Rub'al-Khali work was extended as far as 620 miles from the base camp. Widely spaced structure wells were drilled and several produced potable water.

In the Northwest Concession area structure wells were drilled and one reached a depth of 5000 feet. Geophysical work and structure drilling was also carried out in the Gravel Plains and Northern Summan.

Utilities

Two new steam generators at Dhahran and Ras Tanura increased total steam-generating capacity in the three districts to 2·2 million pounds per hour.

A fourth gas-turbine generating set began producing electricity on 14 November 1955. This installation increased Dhahran power plant capacity to 21,600 kilowatts, and Aramco total capacity to 84,000 kilowatts.

Marketing and Transport

Distribution of refined petroleum products by Aramco in Saudi Arabia in 1955 totalled 2,096,450 barrels, or 345,794 barrels more than in 1954. Refined products were available at 81 locations in Saudi Arabia.

During 1955 the number of tankers which loaded crude oil or products at Ras Tanura was 1758, an increase of 166 over 1954. The 800-foot extension to the north pier came into service and permits the handling of super-tankers. Extensions are in hand at the south pier.

Labour and Training

Over 60 per cent of Aramco's employees in Saudi Arabia are Saudi Arabs and details of the nationality of employees at the end of 1955 are given in Table II.

Six primary schools have been built by Aramco and four others are under construction or planned. Plans are completed for fifty scholarships for selected Saudi Arabs and, under the advanced training programme, fifteen Saudi employees were attending classes in Beirut, Aleppo, and Tripoli.

TABLE I

Aramco Operations in 1955

	1954	1955
Crude oil production		
Total, barrels	347,844,850	352,239,912
Total, tons	46,136,583	46,784,693
Daily average, barrels ...	953,000	965,041
Crude disposal (barrels):		
To Sidon, via Qaisumah ...	116,562,513	117,988,503
To Ras Tanura refinery tanks	79,844,646	74,161,893
To tankers at Ras Tanura ...	84,510,005	96,646,851
To Bahrain	67,214,664	63,150,219
Refining operations (barrels):		
Crude processed	79,844,596	74,171,745
Principal products:		
LPG	—	23,849
Gasoline	—	11,092,263
Jet fuel	—	2,300,793
Kerosine	—	5,377,752
Diesel oil	—	15,177,314
Fuel oil	—	35,401,508
Asphalt	—	209,766
Natural gas		
Marketed production, cu. ft.	—	43,983,860
Injected into Abqaiq reservoir, cu. ft.	—	43,564,697,000

TABLE II

Aramco Employees in Saudi Arabia at the end of 1955

Nationality	*Number*	*Per cent*
Saudi	13,371	65·6
American	2,989	14·7
Pakistani	1,391	6·8
Indian	1,105	5·4
Palestinian	657	3·2
Italian	336	1·6
Adenese	241	1·2
Sudanese	122	0·6
Dutch	43	0·2
Others	142	0·7
	20,397	100·0

Around the Branches

BAHRAIN, FAWLEY, KUWAIT, LONDON, NORTHERN, SCOTTISH, SOUTH-EASTERN, SOUTH WALES, STANLOW, TRINIDAD

At the Bahrain Branch meeting in the Awali Hall on 2 April 1956, under the chairmanship of W. H. Cotter, the guest speaker was T. G. Bibby of the Danish Archaeological Party which had been digging in Bahrain since the winter of 1953 and which, during the 1955-56 season, had been operating in the Portuguese Fort area.

Mr Bibby said that the ancient name of Bahrain was Dilmun and that it was mentioned in the clay tablets of Mesopotamia as a port of exchange, the Sumerians having landed cargoes of wool and taken away copper and gold. The most striking features of Bahrain are the tumuli, claimed by Colonel Prideaux, in 1903, to be Phoenician and by Mackay (sent in the 1930's by Flinders Petrie) to be a burial ground for the mainland, but the latter obviously had not looked seriously.

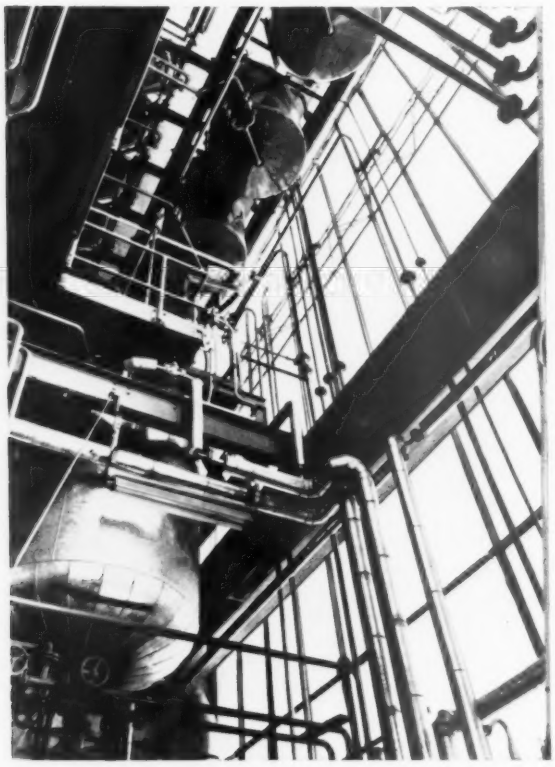
The Danish expedition started searching for dwelling places, and located 40 to 50 sites by means of aerial photographs. They had dug at two grave mounds and found pottery and bronze age pots dating from about 3500-1000 B.C. and had looked for Tels, as in Iraq, but found none on account of the rocky ground. They had investigated a well at Diraz and found statues of bulls and an alabaster vase. They had dug in a mound at Barbar and disclosed a temple, surrounded by two circles of stone, possibly plinths for statues. Here also they had found copper sheathing on a casket and the copper figure of a man, which they had dated Sumerian.

During their second and third years they had also dug at the Portuguese Fort, and were uncovering a large city. This area is the nearest approach to a Tel and pottery discovered here and at Barbar matched that of the Royal Cemetery at Ur—3500 B.C.

The Portuguese Fort diggings disclosed evidence of stratification and while pottery fragments dated the lower layers as Sumerian, 3500 B.C., the upper layers contained Attic and Chinese fragments.

After a discussion in which a number of members took part, a vote of thanks to Mr Bibby for his most interesting talk was proposed by G. C. Baird.

NEW LUBRICATING OIL PLANT IN AUSTRIA



A Shell photograph

The most modern grease unit in Europe forms part of the Shell Austria A.G. new lubricating oil blending installation which has recently come into service at Wien-Simmering, Austria. Planned in 1950, these facilities will add materially to the domestic output of products which previously had to be imported to meet increasing industrial demand. The combination of the new units and the refinery at Floridsdorf will enable the Company to manufacture some 225 products representing 75 per cent of the total it requires for home markets. Indigenous raw material will be used almost exclusively.

The installation consists principally of three main plants—one for grease manufacture, one for oil blending, and one for the manufacture of products from mineral oils and chemical raw materials. The plant will yield high performance greases, including multipurpose greases for automotive and industrial uses.

The lubricating oil blending plant will serve Vienna and the Eastern part of the country, where distribution of these products has recommenced since the Austrian State Treaty.

The third plant will prepare metal-working oils and oils and fibre lubricants for the textile industry as well as agricultural and horticultural products.

The plant covers an area of 12-13 acres and about 3½ million cubic feet of earth had to be moved. Over 12 miles of pipeline had to be laid and sixty pumps are used for transport of products.

The interior of building "G" of the grease plant. The principle of gravity flow has been applied throughout, chemicals and oil being stored in the uppermost tanks. Pipes leading from these tanks end in a centrally-located distribution battery on the first floor and from this terminal the flow of materials is directed into the blending tanks. These insulated tanks, which are recessed into the first floor, can be seen in the left foreground.

Petroleum Research in Alberta

The Research Council of Alberta reports* that investigation had shown the trace metal content of crude oils from Cretaceous age reservoirs is constant, and it was later found that the nickel-vanadium ratio in oils of other geological ages was characteristic. It thus appeared that this ratio provided a means of determining the age of an oil.

Although the nickel-vanadium ratio is constant, the actual quantity of metal in different oils varies and is higher in the heavier gravity oils.

Trace metal and porphyrin contents of crude oils provide a means of approach to the problem of the origin and generation of crude oil.

At present the heavy crudes of Alberta are overshadowed in importance by the light varieties and account for only about 5 per cent of the province's reserves. The black oil market is increasing and the reserve in the McMurray oil sands is estimated to be hundreds of billions of barrels.

Most heavy oils have high sulphur contents and an analytical method for their determination and identification is much needed.

Petroleum Maturation

The three most important factors in the maturation of organic matter to petroleum are temperature, bacterial action, and catalysis.

The temperature factor has been examined for its effect on trace metal content of a maturing crude. The McMurray crude has been matured in a high-pressure reactor at 350–420° C for one to 300 hours. The reaction rates for the removal of vanadium and nickel, about 0·01/hr at 350° C, are of the first order and the activation energies are about 56 Kcal/mol. The reaction rates for magnesium and the porphyrins are appreciably higher. It seems probable that stress must be placed on the importance of catalysis in the formation of crude oil as it is found.

Storage Problems

The settling rates of particles in oil–water emulsions were studied in a form of falling-sphere viscometer. Water concentration ranged from 0 to 35 per cent and temperatures from 70° to 180° F. It was found possible to calculate the settling rate given the dry oil viscosity and the water concentration.

Sulphur Content

Work was carried out on a McMurray oil-sand flash distillate containing 4·37 per cent sulphur. It was shown that extraction methods of sulphur removal were not feasible. Possible methods of desulphurization were thus: (1) catalytic hydrogenation; (2) catalytic decomposition; (3) oxidation. Studies are being made of the decomposition and oxidation methods.

Natural Gas

Work on the engineering evaluation of the permeable tube process for carbon black from natural gas is being published as Mimeographed Circular No. 20. Although no economic evaluation would be valid without semi-works scale tests it is doubtful, in view of the unmistakable shift to oil blacks, whether modifications of existing gas black processes can reverse this trend.

Work on the decomposition of butane has shown that lower partial pressures of butane favour acetylene formation while higher pressures favour ethylene. Acetylene yields upwards of 20 per cent have been obtained and the problem appears to be one of heat transfer rather than one of kinetics.

When the Trans-Canada pipeline is completed, large quantities of butane will be available. It is unlikely that chemical industries will absorb all the gas produced and it will be necessary to develop other uses. A proposed research programme involves design of equipment to permit local use of butane in engines in cold weather.

* * *

WORLD OIL RESERVES

Figures published recently by the Petroleum Information Bureau indicate that, ever since records were kept, the estimated net total of crude oil which can ultimately be recovered from known oilfields, under existing economic and operating conditions, has always risen. Since oil is a "wasting asset", it must be recognized that the world's reserves will eventually begin to fall.

Below are current and previous estimates of proven reserves in the U.S.A. and the World:—

Estimated Proven Reserves of Crude Oil
(million barrels)*

Beginning of year	*U.S.A.*†	*World*
1925	7,500	‡
1935	12,177	23,000
1945	19,785	64,000
1950	24,649	80,000
1954	28,945	135,000
1955	29,561	158,000
1956	30,012	190,000

* 7.3 barrels — 1 metric ton approx. (overall average).
† Estimates of American Petroleum Institute.
‡ Not available.

(1) Of the world total in 1956 over two-thirds is contained in the Middle East.

(2) The above figures do not include natural gas liquids. In the U.S.A. these were considerable and reserves were estimated at 5439 million barrels at the beginning of 1956. No attempt has been made elsewhere to estimate the reserves which may be available from this source.

It will be seen that since 1935 U.S.A. Proven Reserves have increased by nearly 18,000 million barrels, despite the production of over 35,000 million barrels in that period.

Although output was exceptionally high during the last ten years, U.S. proven reserves were estimated at 1 January 1956, to be over 10,000 million barrels more than at the beginning of 1945. In other regions, where prospecting has been far less intensive, more especially in the Middle East, proven reserves are likely to be substantially increased by future discoveries.

*Research Council of Alberta, Thirty-sixth Annual Report, 1955. Edmonton: Research Council, 1956. Pp. 52. 5 cents.

Miscellaneous Oil Products in the Textile Industry

By **F. N. McLAREN**

This paper was read to a meeting of the Fawley Branch on 13 April 1956. *Mr McLaren is on the staff of the Esso Petroleum Co Ltd.*

Introduction

Several raw materials derived from petroleum are playing an increasing part in the production of textile fibres. For many years, petroleum derivatives have provided raw materials used in producing certain types of regenerated fibres, *e.g.* acetate rayon, and more recently the advent of the synthetic fibres has opened up considerable markets for petroleum derivatives as feedstocks. These markets will continue to expand for some time to come. The complete replacement of the natural fibres is not envisaged: there are many men who still regard a fine poplin as the best shirting material, and the unique properties of the wool fibre make possible the production of fabrics which cannot be reproduced by using any regenerated or synthetic material.

The Wool Fibre

The difficulty of making a complete replacement for wool is indeed formidable. It is, of course, possible to make a fibre which chemically resembles wool; indeed this is already being done on a commercial scale. Nature has endowed the wool fibre with a physical characteristic (later referred to in greater detail) which gives it the unique property of felting. Felting is a form of shrinkage, and when this happens to a pair of socks or a cardigan it is rightly regarded as a nuisance. But without felting the manufacture of some of our more luxurious woollen suitings and overcoatings would be quite impossible.

Use Development of Man-made Fibres

Expansion of the demand for man-made fibres will continue on a two-fold basis :—

(1) Their use in applications where their special properties are particularly valuable. Development is proceeding rapidly, and is dependent on the perfection of manufacturing techniques which enable these properties to be fully exploited. Traditional methods of yarn and fabric construction are often unsuitable for the new materials.

(2) Extension of their use in conjunction with the traditional materials. By the judicious use of man-made fibres in conjunction with cotton, wool, and other fibres it is possible to produce materials with improved properties, such as better wear and crease resistance, dimensional stability, etc. Here again, intensive development is proceeding on new manufacturing techniques leading to better ways of combining the traditional and the new materials. Some highly successful results have already been achieved—the marriage of Terylene to wool in the production of improved worsted-type materials is a good example.

Detergents from Petroleum

No discussion of the connexion between petroleum and textiles would be complete without some reference to detergents. The spectacular success of synthetic detergents in the domestic market is obvious. The use of these materials as replacements for the soaps used in the textile manufacturing industries is also proceeding, but at a slower rate. One factor affecting this market is the use in certain sections of the industry of soap-making materials such as the oleins which are used for fibre lubrication. Washing in dilute alkali leads to the production of soap *in situ*, often rendering the use of additional detergents unnecessary. Here then, the economics are not so simple and straightforward as in the domestic field; but in other sections of the industry, where synthetic detergents can compete with finished soaps on more or less level terms, the new materials are winning friends. However, the industry is traditionally conservative, and new ideas are only accepted after cautious and prolonged evaluation. Moreover, most textile manufacturing plants have supplies of soft water, and thus the usual advantage of synthetic detergents over soap is not so marked. The advent of the new materials does, however, suggest the possibility of locating textile finishing plants in areas where a naturally occurring supply of soft water is not available. Alternatively, those plants which have installed water-softening equipment might be able to dispense with its use.

The markets so far discussed—man-made fibres and synthetic detergents—are likely to be the main textile outlets for chemicals from petroleum. Many finished petroleum products are also consumed by the textile industry, and these include fuels, lubricants, solvents, and certain minor products.

Steam Raising

The textile industry uses a great deal of steam for processing, space heating, and as a means of driving its machinery. Traditionally, this steam has been derived from coal, and indeed the major part of the British textile industry is located close to the coalfields of Lancashire and Yorkshire. Conversion of boiler plant to oil firing is, however, taking place, but not perhaps on so large a scale as in other industries and locations where the economics are more favourable to oil.

The present-day trend in textile plants is to use individual electric drives for the various machines, as is done in the U.S.A. Consequently, the industry is taking more and more electricity from the Central Electricity Authority, and this is particularly true in the spinning and weaving sections of the industry, where requirements for process steam are not so great. However, in the dyeing and finishing plants, which consume considerable amounts of process steam, large boiler installations will be retained. It is in such plants that the largest

potential market for fuel oil exists, and provided the economics are favourable there is every likelihood of conversions to fuel oil.

Diesel Power

The installation of diesel powered generation equipment in some mills requiring relatively small amounts of process steam has also taken place. But bearing in mind that these plants only require diesel fuel to generate electricity, no great expansion is anticipated at present. Supplies of electricity from the grid are becoming more plentiful, and they are competitive in price. The installation of diesel-driven generators was a useful short-term measure in the critical post-war years when the textile industry's need for electricity was often too great for the public supply of this commodity. Such installations will still give useful service where local conditions are favourable, but as a general comment it seems unlikely that large-scale dieselization of the textile industry will take place. Thus, the main textile outlet for petroleum fuels is likely to be the heavier grades of residual fuel oil which will be used for steam raising.

Solvent Degreasing

The use of solvents in the U.K. textile industry is somewhat limited in scope, being mainly confined to the waterproofing industry and certain specialized applications and cloth finishing processes. One possible large-scale use of petroleum solvents is for the degreasing of raw wool. The usual practice is to remove the wool grease in aqueous solutions of mild alkali. It is a cheap and effective method, but does not permit of easy recovery of the useful by-products, which the resulting effluents contain, except on a large scale, such as is practised by the Bradford Corporation's by-products department. Here, the concentration of raw wool scouring plants makes it economically feasible to operate a recovery process, with benefit to the ratepayers. But it should be remembered that the Bradford Corporation had a major problem on their hands—how to dispose of the very large amounts of impure wool grease reaching their sewage works and interfering with the processes. Recovery and sale of the by-products of wool scouring was an intelligent solution. The alternative—solvent degreasing—has been in use for many years in one large plant in the U.S.A., but the system has never been generally adopted. In this American process, large batches of wool are loaded into a vessel where they are subjected to the degreasing action of a light petroleum fraction. Recovery of both solvent and wool grease is of a high order of efficiency, and the latter finds a ready market with ointment and cosmetics manufacturers, etc. Presumably the economics are satisfactory, and they may be influenced by the existence of local markets for the resulting by-products. This is a batch process, geared to the rate of production in other departments, but in woollen mills using the conventional scouring methods the process of degreasing is carried out continuously so that flow production is possible. Development of a continuous solvent degreasing process does not present any formidable practical difficulties, but the capital cost of the plant would be very high, and would be difficult to justify economically. One of the main requirements would be a high order of safety against fire risks. Wool is an expensive commodity, the price of which fluctuates considerably. The effect of this is to cause the large mills to carry large stocks, often bought when the market is favourable, and because of this the insurance premiums are heavy. The introduction of highly inflammable materials into the processing sequence would undoubtedly cause the underwriters to revise their rates, perhaps to prohibitive levels. Thus, as things stand, the economics of the large-scale solvent degreasing of wool do not look very favourable; but the subject is being studied and the possibility of developments cannot be excluded. These are most likely in plants where the wool degreasing equipment is housed in a building separated from the other manufacturing units, or in any entirely new plants which may be built.

Lubrication

Lubrication is a field that offers many interesting problems for the petroleum technologists. There are, of course, many lubricant applications on the machines themselves, and several of these call for specialized products. In addition, there are considerable markets for fibre lubricants, some of them also highly specialized.

Machinery Lubricants.—Dealing first with machine lubrication, one of the ever-present problems associated with the production of textiles is the avoidance of stains. Stains caused by oil—particularly dirty oil—are a source of annoying and often serious losses to production. Moreover, the source of such stains is not always easy to trace in a large and complex manufacturing plant which uses literally dozens of processes. The design of the machines themselves is not always conducive to clean processing. Many of the bearings are simply open bearings to which the lubricant is applied from an oil can, and when this operation is performed by unskilled labour the results can be disastrous. Clean oil on yarn or fabric is bad enough, but dirty oil is very much worse. Some of the most troublesome stains are caused, not by the oil itself, but by finely divided metal fragments which have been worn from bearings. Such contaminants can cause severe and permanent staining or variations in shade of dyed or printed goods. They can discolour white materials, and can affect to a startling degree the levelness of any dyes which are subsequently applied, making the goods unsaleable.

Many of the newer textile machines are better designed from this point of view than their predecessors. The wider application of sintered metal and grease-lubricated anti-friction bearings minimizes the likelihood of dirty lubricants getting on to the materials being processed, but there is a vast amount of old machinery still in use. From the oil companies' point of view, the problem of staining can be attacked by providing suitably compounded oils which themselves are fairly easy to wash out from textile materials by emulsification processes, but this does not entirely overcome the difficulties associated with dirty oil getting on to the stock. Here prevention is better than cure and the intelligent application of non-drip, non-throw lubricants can do much to minimize the problem. Additives are available which literally make an oil stickier without any proportionate increase in viscosity and the use of lubricants containing suitable amounts of these materials can minimize drip from overhead mechanisms and throw from the rapidly moving cams and gears which are features of many textile machines.

Specialized Applications.—Special types of lubricating oil are required in certain applications. About two years ago legislation was introduced which makes the use of highly refined white oil obligatory for the lubrication of the spindles of cotton spinning mules. This legislation was the result of protracted investigation into the causes of an occupational disease in the cotton industry (mule spinners' cancer), and it is interesting to note that mill tests have

shown that power consumption of the machines so lubricated is no higher than was the case when less highly refined lubricants of similar viscosity were used. This seems to prove fairly conclusively that the cotton mule spindle operates throughout its cycle under hydrodynamic lubrication conditions. If this were not the case, and if partial or boundary film conditions applied, highly refined white oils would be at a disadvantage, since under such conditions the different chemical constitution of conventionally refined spindle oils gives them somewhat better load-carrying ability. But the ability of a fluid to provide a hydrodynamic film is largely independent of its chemical nature, and is determined chiefly by its viscosity.

Cotton Oiling.—The practice of oiling cotton during processing is by no means universally followed. However, it is met with fairly frequently in the mills of North America and, to a lesser extent, in Europe. The practices and materials differ widely in these two areas, but the market potential for any given state or country can be calculated as about 0·2 per cent of the weight of cotton being processed. If more than about 0·25 per cent is applied, certain undesirable effects are noticed, while if less than about 0·15 per cent is used, little or nothing is achieved.

Generally, the North American mills use a straight paraffinic oil although sometimes pale neutral oils are used. Some firms prefer an oil which contains a small amount of wetting agent, as this is said to assist penetration or distribution, but if the system of application is efficient, this is hardly necessary.

Two methods of application are commonly used :—

(1) Spray atomization in the scutcher (picker) feed or in one of the opening machine feeds.

(2) Direct application by seepage from a tube in the beater chamber of the scutcher (picker).

It is believed in some quarters that oil is applied to cotton as a fibre lubricant, but its usefulness in this respect is doubtful. Rather it serves to condition the fibres and to provide better fibre control by helping to minimize static and eliminate loose or "wild" fibres. Also, it assists materially by suppressing dust and "fly" which can cause great discomfort to certain personnel who may have allergic respiratory conditions.

If more than about 0·25 per cent of oil by weight is applied to cotton, yarn strength begins to be affected, and this is attributable to a reduction in inter-fibre friction caused by unnecessary lubrication.

In the U.K. and certain European countries a different system has been adopted. Here, an emulsifiable oil is used, and this is applied by atomizing spray at an early stage of the processing, where it can provide a most useful control on dust and "fly". Any oil which is capable of providing a stable emulsion of low viscosity is quite suitable for this system. The quantity applied, *i.e.* about 0·2 per cent by weight, is the same as for straight oil, but here some water is introduced as well. This in itself is useful under conditions of low humidity.

The cotton fibre is most easily processed when the ambient air is warm (about 80°–85° F) and damp (about 50–60 per cent relative humidity). If it becomes much colder or drier the fibre becomes less flexible and, therefore, more easily broken, and in addition, the effects of static electricity can make it almost unmanageable.

In a fully air-conditioned mill, with an efficient dust extraction system, the benefits of cotton oiling are not so apparent as they are in an old mill where temperature, humidity, and the cleanliness of the atmosphere are suspect.

Coarse Vegetable Fibres

The "coarse" fibres represent a considerable market for process oils. The requirements are not critical, but as most of the products of the industry, *i.e.* sacks, ropes, cordage, etc., are sold by weight there is a natural preference for high gravity oils provided the price is right, this being a highly competitive market. Some manufacturers of high-quality light-coloured ropes and cordage prefer products of good colour stability, and this requirement may conflict with that for a high gravity oil, so that some compromise is necessary. In the U.K. the most widely-used oil is a pale spindle oil.

In many of the manufacturing processes the oil is applied straight, but sometimes emulsions are used. Where this applies, the practice of the larger mills in the U.K. is to incorporate their own inexpensive emulsifiers. These are purchased direct from chemical firms specializing in this market. There is also a trade in inexpensive "batching creams", which are really heavy emulsions produced by mechanical means from inexpensive ingredients.

The function of the oil in all cases is to lubricate and soften the harsh and often brittle fibres, to keep static effects to a minimum, and to help lay the large amount of dust and dirt which the fibres contain.

Wool

The woollen and worsted industries use considerable quantities of oleins and fatty oils each year. Although the precise quantities involved are not known, it is possible to calculate reasonable estimates from the figures for woollen and worsted productions published by the Board of Trade. In this way, it is estimated that during 1955 the woollen and worsted industries used some 15,000 tons of oleins and fatty oils as fibre lubricants.

For several years, it has seemed to the oil industry that here exists a potentially profitable market for specialized petroleum products. Efforts have been made to break into it, but only a very limited success has been achieved. It is pertinent to consider the reasons for this, but before doing so it is necessary to examine some of the factors which affect the situation.

The Wool Fibre.—Wool is unique among the textile clothing fibres in having a rough, scaly surface. Moreover, the surface irregularities are so arranged that the fibre has different frictional properties from root to tip than it has in the opposite direction. This peculiarity of the wool fibre causes a mass of wool to become entangled and matted very easily—the individual fibres do not slide freely over one another. Freedom of movement is essential during many of the early manufacturing processes, and this can be achieved by the application of a suitable lubricant. The commonly used lubricants are oleins and fatty oils, the former being used mainly in the production of woollen goods, and the latter for worsted materials.

Woollen and Worsted Processes.—At this stage distinction should be made between the woollen and worsted processes. In both cases, the raw material is wool (though adulterants are often used in both processes) but the end products are different. The difference between, say, Harris Tweed and a fine bird's eye worsted are well known. In the production of woollen yarns the individual fibres are not laid parallel to one another before spinning and a relatively loose and "hairy" yarn results. In worsted manufacture additional processes are used in which the aim is to achieve parallelization and take out unwanted short fibres. The resultant yarn is generally

harder and more compact. There are other differences between the two processes, and indeed different types of wool are used in them, but these need not be of concern here. The point to be made is that in the production of woollen yarns the main fibre lubricant is olein, while in worsted manufacture the commonly used lubricant is a blend of castor and arachis oils, with an added anti-oxidant. Consumption of olein for fibre lubrication is considerably greater than the consumption of fatty oils.

"Olein"

The term "olein" describes oleic acid of varying degrees of purity, ranging from a low-grade product with 50 per cent free fatty acid to a fairly pure variety with over 95 per cent free fatty acid. The prices vary according to purity, the better grades being used in the high-class woollen trade and vice versa.

Olein is by no means an ideal fibre lubricant. It oxidizes readily and fouls the processing machinery with sticky deposits which collect various solid impurities such as the wool fibres themselves and any solid materials which may be present in the atmosphere. But it has one considerable advantage : it is easy and cheap to remove once it has fulfilled its purpose. When the manufacturing processes have been completed it must be washed out almost completely—at any rate down to a level not exceeding 0·5 per cent by weight on the clean wool. Such a low residual figure is not difficult to attain with a good olein : rinsing in aqueous solutions of a mild alkali (sodium carbonate) produces (by chemical reaction) water soluble soaps, and these soaps have the suspending power necessary to wash out any unwanted materials which may be present. The process of saponifying the olein and final cleansing of the cloth or yarn can be achieved in two simple stages :—

(1) Rinsing in mild alkali which produces soap followed by continued washing in the soapy liquors.

(2) Washing clean in water.

Mineral-based Wool Oils

Attempts to replace the oleins used in the woollen industry by petroleum products have in recent years been concentrated mainly on the use of emulsifiable mineral oils. Such oils have been shown to have better performance as fibre lubricants than the existing materials. For instance, their oxidation stability is much better, and the cleaner processing which results has been reflected in higher productivity in the mill. But final removal has not been so uniformly successful, and even when an acceptably low residual oil content can be achieved it is usually necessary to use some soap in order to rid the pieces of the dirt which the oil-in-water emulsion has little power to remove. Thus, the cost of the final cleansing processes is increased, and the economics may not be attractive. Again, if the final cleaning processes are unduly prolonged damage may be sustained by the pieces : for instance, excessive shrinkage may occur.

Objectives.—The problem of replacing oleins as fibre lubricants is by no means solved, but as immediate objectives, which could lead to the development of a successful mineral-based wool oil, the following are suggested :—

(1) The development of efficient, low-cost emulsifiers of consistent quality which would give the resultant oils a decisive price advantage over oleins, thus making the use of soap for cleaning the pieces economically permissible.

(2) Development of an emulsifiable oil which when emulsified will have considerable dirt-suspending power, thus making the use of additional detergents unnecessary.

The Worsted Industry

In the worsted industry the difficulties to be overcome are essentially similar, although other factors enter into the picture. The fatty oils which are used as fibre lubricants are removed in a different manner from the oleins used in woollen processing. The latter are saponified, but the fatty oils used for worsted yarns are emusified in dilute alkali and soap solutions—such solutions, in fact, as would seem to be suitable for removing an emulsifiable mineral oil. At first sight, the worsted industry would seem to present an ideal opening for mineral-based fibre lubricants. But here the organization of the worsted industry introduces a complication. Unlike woollen firms, which usually have a "vertical" organization, *i.e.* all processes carried out by one firm, worsted manufacturers rarely carry out all stages of production in a single unit. The industry is organized in groups which carry out the different stages of manufacture—top-making, spinning, dyeing, fabric making, and finishing. Without going into too much detail, the net result of this is that the firm at the end of the line—the fabric maker and finisher—may have in his cloth wools which originated in a number of different plants. This makes it very difficult to carry out controlled experiments : one cannot always be certain that the cloth on test in the final oil-removing operation contains only the one oil which it is desired to test. Other oils may have been introduced to part of the yarns used.

Standardization.—These difficulties have led the industry to standardize on the use of a single type of oil, and there is extreme reluctance to depart from this standard. During the war, when fatty oils became difficult and expensive to obtain, experiments were carried out with possible substitutes. These tests, and the difficulties that ensued have not been forgotten. The oil industry's first requirement here therefore seems to be to produce an oil which is completely compatible with the present fatty oil formula, an oil which will be removable by the same methods, alone or in the presence of the existing oil. Such an oil could be introduced gradually—its eventual success would be a matter of economics.

Regenerated Fibres

The fibres in this group consist of the regenerated cellulosic fibres—viscose, acetate, cuprammonium ; and the regenerated proteinic fibres such as Ardil, Vicara, etc.

All these fibres are used in various ways :—

(a) by themselves.

(b) in blends with other regenerated or synthetic fibres.

(c) in blends with natural fibres.

The cellulosic fibres require lubrication during processing in order to minimize abrasion and also to reduce the effects of static electricity. Low medium viscosity white oils are eminently suitable for this purpose, and according to the needs of the process are applied straight or with additives. These latter are highly specialized formulations made by chemical manufacturers, usually in close collaboration with the fibre manufacturers, who, incidentally, regard their formulations as highly confidential.

White oils are also used as delustreants where a highly

reflective surface finish on the fibres is not desirable in the finished article.

Most of the regenerated fibres are produced in two main forms, continuous filament or staple. In the latter form, they are cut up into short lengths or staples ; and as such may be processed on cotton machinery into yarn and fabric either by themselves or in combination with cotton. Alternatively, they are sometimes blended with wool and processed on the woollen system. If this is done, they receive the same lubricant as that required for the wool.

The proteinic fibres are produced almost exclusively as staples of different lengths, and they are used largely in blends with the natural fibre, wool. Here again, they are treated along with the wool, and are lubricated accordingly.

As the market for regenerated fibres, already large, continues to expand, so will the demand for fibre lubricants. In general, however, it appears likely that the oil industry will continue to supply base oils only, mainly highly refined white products. It seems unlikely that specialized, finished products containing additives will be developed, as the structure of the rayon industry, and its research facilities, are such that fibre development and lubrication go together hand in hand, with the oil industry supplying some of the basic raw materials. This is not perhaps a bad thing, as the research necessary to develop specialized fibre lubricants is necessarily expensive, entailing, as it does, the acquisition of much expensive plant which already exists elsewhere—in the research establishments of the major fibre manufacturers.

Synthetic Fibres

Many of the foregoing remarks apply to the process requirements of the synthetic fibres. These new materials, which are rapidly gaining in popularity, include such well known trade names as nylon, Terylene (Dacron), Orlon, Acrilan, Dynel, Vinyon, and Saran.

In general it can be said that this group of fibres differs from the regenerated fibres in two major respects :—

(1) They have better abrasion resistance. This makes the need for lubrication, as such, somewhat less severe, and results in the use of products of rather lower viscosity.

(2) They are poor absorbers of moisture. This property makes the control of static a factor of even greater importance, but helps to reduce scouring problems.

As with the regenerated fibres, research into fibre lubrication and static control goes hand in hand with production research, and is conducted mainly in the manufacturer's specialized laboratories. The oil industry's major role is to supply raw materials, but there are indications that some product research may be necessary, *e.g.* highly finished white oils of low viscosity are required in the processing of nylon. There are indications that still better results could be obtained from products having even lower viscosity if this could be achieved without lowering the flash point or increasing the evaporation rate. This might result in the oil industry being called upon to supply specially prepared petroleum fractions with a narrow distillation range.

Conclusions

It will be apparent that the oil industry has many contacts with, and markets in, the textile industry. An attempt has been made to define some of the more important of the latter, and to indicate where possibilities for expansion exist. It will be apparent too, that the textile industry's needs offer the petroleum technologist problems which are well worth solving. The petroleum industry has every reason for satisfaction in the contributions it is making to the processes of another important basic industry. But there is no reason whatsoever for complacency—unsolved problems still exist, and their solution can lead to an even more fruitful and profitable collaboration than has existed in the past.

U.S. BUREAU OF MINES REPORT

During the 1957 fiscal year, the Department of the Interior, Bureau of Mines, plans to seek improved production methods for the recovery of more of the oil in the U.S. underground petroleum deposits. Studies will be made in order to develop a better understanding of well-drilling fluids and their effects, and it is hoped that laboratory research will determine whether tiny amounts of metals and other elements in oil are major factors in the tendency of certain oils to resist efforts to extract them and "stick" underground.

The Bureau will also continue the laboratory and field tests of detergents which have shown promise in washing oil out of tight formations in secondary recovery projects. Co-operative engineering studies are to be conducted at selected oilfields in the U.S.A.

It will study leakage and other problems encountered in storing gas underground, and conduct further research on transportation of oil and gas by pipeline.

Basic research on sulphur and nitrogen compounds, whose presence in crude oil causes refining difficulties, will continue, and the Bureau will collect and publish additional information on characteristics of crude oils in the U.S.A. Factors affecting the stability of various fuels in storage will be investigated further.

The Bureau will continue to study, with the aid of a "constant-volume ignition bomb", the reactions that take place during combustion of diesel fuels. This research is aimed at promoting more efficient use of diesel fuels and may eventually result in the development of superior diesel equipment.

Experiments in mining and retorting oil shale, confined to mining research since July 1955, have been discontinued. Laboratory studies will, however, continue with a view to obtaining more information about the nature and properties of kerogen, and the products that can be made from it.

Although Congress approved the Bureau's request for an additional amount of approximately $2 million to be spent on increased research in strategic metals and minerals, funds for work on oil shale and economic and statistical information on domestic and foreign minerals were reduced.

The appropriation for helium research is the same ($94,700) as last year's. The Bureau's $6 million helium expansion programme is well under way.

The Bureau's work is also designed to supplement research performed by the petroleum and natural gas industries, especially in connexion with transportation, storage, chemistry, and refining.

Notes of the Month

Exploration in Sicily

With a view to providing information on which to choose the site for a second test well, BP has begun seismic survey operations in S.E. Sicily.

Bulawayo Cup

For the most conspicuous efficiency in Fleet replenishment service in the Mediterranean area in 1956, the Bulawayo Cup has been awarded to R.F.A. *Retainer*.

Egmanton Production

In the first year of production at Egmanton, nine wells have been sunk and production has steadily increased to the present level of 1000 tons a month.

New Units for Refineries

A 400,000 tons a year hydrofiner, for removing sulphur from gas oil, and a 350,000 tons a year catalytic reformer, for producing a high-grade motor spirit component, are to be installed at BP and Petrofina's Antwerp refinery.

Two similar catalytic reformers are to be installed at BP's Dunkirk and Kent refineries.

More Test Drilling in Papua

BP in association with Australian and American interests have started drilling another deep test well in Papua. The new site, known as Barikewa, is 4 miles south-west of the middle reaches of the Kikori River.

A rig is being erected 30 miles inland, close to the Morehead River, for a second deep test well. Drilling is expected to commence shortly.

The Institute of Physics

At the Annual General Meeting of The Institute of Physics held in London on 16 July, O. W. Humphreys (director of the G.E.C., in charge of research) was elected President; Dr B. P. Dudding was elected a Vice-President; Dr J. Taylor, Honorary Treasurer; and Professor F. A. Vick, Honorary Secretary. The two new Ordinary Members of the Board elected were Dr L. R. G. Treloar and G. W. Warren.

Sir George Paget Thomson was elected to Honorary Fellowship in recognition of his contribution to physics and his services to physicists.

Fellowships for Advanced Study and Travel in the U.S.A.

Twenty Commonwealth Fund Fellowships are available to British subjects who are degree graduates of a U.K. university, for study and travel in the U.S.A. The Fellowships provide for all expenses of travel, study, and living.

Candidates must be available in London for interview in March 1957. Age: 23 to 32 years. Tenure: 12 to 21 months. Closing date of applications: 15 December 1956. The appropriate memorandum with application form attached may be obtained through British Universities or from The Warden, Harkness House, 35 Portman Square, London, W.1.

Science Abstracting

The establishment of the ICSU Abstracting Board, which is affiliated to the International Council of Scientific Unions, has led to notable improvements in science abstracting, claims UNESCO.

As a further aid, the *Monthly Bulletin on Scientific Documentation and Terminology* is to be extended and UNESCO has decided to encourage the adoption of the *Guide for the Preparation and Publication of Synopses*—a leaflet which is supplied free of charge to editors of scientific journals to pass on to contributors.

Analytical Chemistry Congress

The Society for Analytical Chemistry, through its Scottish Section, is organizing a Congress to be held from 24 to 28 June 1957 at St. Andrew's University.

Among subjects to be discussed are gas chromatography in the petroleum industry and new analytical methods in the plastic industry, etc. There will be a section on modern techniques and instrumentation covering automatic titration and the automatic recording of spectra in relation to industrial problems of analysis.

The Congress aims at reviewing the likely future developments in analytical chemistry, the impact of new instruments, the relationship between official laboratories and chemists in industry, and the possibilities of geochemical prospecting. There will be an exhibition of the newer types of apparatus.

The Congress Secretary is J. A. Eggleston, Boots Pure Drug Co Ltd, Airdrie Works, Airdrie, Lanarkshire.

Nigeria Oil Search

After spending £1 million on test wells in the Akata area in the South East of Nigeria, Shell BP Petroleum Development Co now considers that the possibility of a commercial oilfield existing there is extremely remote. The latest well —Akata No. 8—has just been completed at 7800 ft without encountering oil or gas.

Costing about £300,000, the first wildcat in this area encountered oil in sufficient quantities to encourage further drilling to see if an accumulation existed which could be rated as commercial. It now seems that only a very minor reservoir was located—too small to warrant the construction of production facilities. The company has no plans for further test drilling on this structure for the time being.

Further drilling will now be concentrated on other structures which may offer better prospects.

Shell's Californian Synthetic Rubber Plant

Extensions costing several million dollars are being made to the Shell Chemical Corporation's synthetic rubber plant at Torrance, California. Shell purchased this complex from the U.S. government last year and immediately started a modernization programme designed to meet the growing and changing demands for synthetic rubber. It is the only plant of its type west of the Rockies and is now the main supplier there of this material for car tyres, floor coverings, and other rubber goods.

A new unit, to be finished this autumn, is being built to produce special synthetic latex for foam rubber goods. The copolymer plant for the manufacture of synthetic rubber is being enlarged and its capacity raised from 89,000 tons to 110,000 tons per year of a wider range of rubber types.

Further, the butadiene unit at Torrance is being extended in order to provide the increased quantities of this essential raw material.

Besides its additions to the manufacturing plant, the company is also building a new research laboratory and pilot plant which will enable Shell Chemical Corporation to expand its already considerable research effort in the field of synthetic rubber.

Society of Chemical Industry Corrosion Group

The judges of the 1956 Essay Competition experienced great difficulty in selecting the winning entry from the total of fifteen received.

They consider that the high quality of several of the entries should be recognized by an increase in the total prize money and by the award of one prize of 20 guineas and two of 7 guineas each instead of one prize of 25 guineas. They have accordingly awarded a prize of 20 guineas to J. F. Light (Bexleyheath, Kent) for his entry "The Problems of Corrosion Interference Associated with the Application of Cathodic Protection to Buried Structures" and prizes of 7 guineas each to R. Tate (Montreal, Canada) for his entry "Corrosion: its Implications to Aircraft" and to M. A. Pearson (Birmingham) for his entry "Hydrazine as a Corrosion Inhibitor." They also wish to express their commendation of the entry of G. M. W. Mann (London)—"The Use of Statistics in Corrosion Research."

In assessing the entries, the judges have considered literary style, originality of thought, arrangement, and development of argument.

Commander-in-Chief The Nore Visits Oil Tanker

A BP photograph

Admiral Sir Frederick Parham, K.C.B., C.B.E., D.S.O. (C.-in-C. The Nore) visited BP Tanker Company's 32,000-ton oil tanker "British Soldier" at the Kent oil refinery on 29 August. Admiral Sir Frederick Parham is seen here (third from right) *with the Master (Commodore S. D. Bumstead,* fourth from right) *and officers and apprentices aboard the tanker.*

Pictorial Markings for Packages

The British Standards Institution has recently published a new British Standard (BS 2770) "Recommendations for pictorial marking of handling instructions for non-dangerous goods." This standard recommends the use, on containers of "non-dangerous" goods, of pictorial marks which provide at-a-glance instructions to all concerned with the handling of a package during transit. Thus, the conventional wording "Fragile—handle with care" is expressed by the stylized symbol of a slender-stemmed wine glass.

Five other marks recommended in the standard cover are those which are considered to be the most important instructions in the language of freight handling:—

Use no hooks—do not puncture

This way up

Keep cool—stow away from boilers

Sling here

Heavy weight this end.

It has been proposed that the International Organization for Standardization (ISO) should study this subject with a view to preparing internationally acceptable recommendations.

The recommended symbols are illustrated in BS 2770 in the form of stencil markings so that they provide a basis for the manufacture of suitable stencils.

Copies of BS 2770 are obtainable from the British Standards Institution, 2 Park Street, London, W.1, price 3s. each.

Booby Traps

Three persons killed every day and nearly 185,000 injured every year—that is the cost in pain and suffering which is borne by British industry. On the economic side, the loss amounts to 20 million man-days a year; out of a labour force of 7 million workpeople about 80,000 persons are absent from work at any one time.

With these facts in mind, The Royal Society for the Prevention of Accidents commends its Industrial Safety Campaign—the object of which is to encourage all workers to be "safety conscious," *i.e.* to cultivate safe habits in working so that neither they nor their workmates are subjected to unnecessary hazards. During National Industrial Safety Week (5-10 November 1956) workers in every factory throughout the country will be warned by posters and other propaganda to "Look Out For Booby Traps"—the collective name adopted for hazards that range from defective tools to careless behaviour. During the week—and after—managements are asked to keep the "Booby Trap" slogan before their workers and to do everything possible to encourage safe working.

ASSAM DRILLING RECORD

Nahorkatiya Well No. 18 of the Assam Oil Co was recently drilled to 10,400 feet in 24 days, thus establishing a new record for the field. Another record achieved during the drilling was 2625 feet in three 8-hour shifts. Satisfactory results from the well are expected.

What Oil Means to Britain

"What oil means to Britain" is the title of an informative pamphlet published recently by the Petroleum Information Bureau. The pamphlet states that British companies, sometimes associated with Dutch interests, produce in a score of different countries—including the U.S.A. —about 120 million metric tons of crude oil a year. The importance of their total oil production to world oil trade can be appreciated when it is noted that they are responsible for producing more than a third of all oil entering into international trade (which excludes oil produced and consumed in the U.S.A. and the U.S.S.R.).

Britain's New Refining Industry

Between 1947 and 1955 refining capacity was raised from 2,500,000 tons a year to some 30 million tons a year. It is noted that the smallest of these new refining plants is alone capable of refining nearly as much oil as the entire British refining industry in 1947, and the largest can process over 7 million tons of crude oil annually.

The development of the new refineries in the U.K. at an estimated total cost of £20 million has not only eased Britain's expenditure of foreign currency as a result of importing crude instead of refined products but also enabled the country to export, in 1955, refined products valued at nearly £80 million. The pamphlet also draws attention to further advantages of Britain's enhanced refining capacity, *e.g.* the production of petroleum chemicals and sulphur recovery plants.

Tanker Construction and Equipment Manufacture

To provide for the world-wide transportation of crude oil and refined products, the U.K. owns the second largest tanker fleet in the world. In mid-1954 the combined carrying capacity amounted to 7 million tons, *i.e.* about 20 per cent of total world tanker tonnage (vessels of 2000 tons dw and over). Moreover, at the end of 1955, over 40 per cent of all tonnage on order in Britain's shipyards was represented by oil tankers, while orders for oil industry equipment placed with British manufacturers have averaged about £90 million p.a. in recent years, and in 1955 amounted to over £120 million.

The Foreign Exchange Position

The important earnings of foreign exchange resulting from overseas sales are also noted. Further, the overseas production and sales of oil by British companies, (and the associated Dutch interest) coupled with the tremendous expansion of refining capacity in the U.K. and the development of the British oil equipment industry, are all of considerable importance to Britain's economy. In the case of British companies overseas, production has increased from 66 million tons in 1947 to about 120 million tons in 1955.

The great expansion which has taken place in the past few years has inevitably involved the companies concerned in vast expenditure—a great proportion of which has been provided out of earnings. Some while ago it was estimated that a capital expenditure of about £40 is necessary for every ton by which the annual output of finished products is increased.

A yet further important factor in the reduction of Britain's foreign exchange commitments arises from agreements entered into between various U.S.-controlled companies operating in the U.K. and the British Government. As a result of this agreement the companies in question are now able to supply petroleum to the sterling area without incurring dollar expenditures any higher than those incurred by British and British-Dutch companies.

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WITHOUT COMMENT

The recent earthquakes in India and on that Greek island were, comparatively, minor affairs, but great earthquakes in different places are inevitable.

You cannot extract millions of tons of crude oil from the depths of the earth, without inviting catastrophe. Oil is a lubricant. Coal, iron, copper, tin—are not lubricants. There are two hundred registered oil companies.

When I found that one company had completed the extraction of two million tons, I asked an engineer, "What happens when you remove a lubricant from where it may be needed?" He said, "you get friction." Exactly, you get friction, but how many can see the point?

The 21st chapter of St. Luke deserves more attention than it gets.

CAPT. W. STANLEY SHAW,
2 Hobart-place, S.W.1.

This letter appeared in the West Kent Mercury *recently.*

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EUROPEAN CONVENTION OF CHEMICAL ENGINEERING

The European Federation of Chemical Engineering has decided to hold its Second Congress within the framework of the European Convention of Chemical Engineering. This Congress will be in Brussels from 28 to 30 May 1958 and will continue in Frankfurt am Main from 31 May to 8 June 1958. The European Federation of Corrosion is also planning to hold its Second Congress in Frankfurt am Main.

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INTERNATIONAL CONGRESS OF CHEMISTRY

The XVI International Congress of Pure and Applied Chemistry will be held in Paris from 18 to 24 July 1957. It has been planned to coincide with the XIX Conference of the Union, and will be preceded by the celebrations of the Centenary of the French Chemical Society.

The Congress will have three divisions:—

(1) Physical Chemistry

Physical-chemical aspect of radio-elements. Combustion of gas mixtures. Water in chemical compounds. Diffusion in liquids and gels: reactions and structures.

(2) Mineral Chemistry

Solid combinations of metals of transition. Compounds of boron with metalloids. Chemical properties of actinic (Fr. Actinides) elements. Chemical properties of bodies at high temperature.

(3) Organic Chemistry

Mechanisms of intramolecular reactions and transpositions. Organo-metalloid compounds. Selective reactions and phenomena of orientation: stereochemistry. Structures and synthesis of natural compounds (excepting macromolecular products). Further details will be published in the near future.

Personal Notes

H. W. H. Icough, works director of G. A. Harvey & Co (London) Ltd, recently retired after nearly 50 years' service with the Company. Mr Icough was chairman of the Executive Committee of the Woven Wire Manufacturers Association from 1942 until his retirement this year. He was also Mayor of Greenwich for the year 1938–39 and, in 1953, as a reward for 25 years of public service, was made a Freeman of that Borough.

Michael S. Reford has been appointed geophysicist of Canadian Aero Service Ltd of Ottawa. Previously, Mr Reford was geophysicist in charge of Mobil's Western Saskatchewan District.

A. G. B. Owen, chairman of the Owen Organisation, has joined the executive committee of the Welsh Economic Development Council, the organization formed in 1954 to develop existing industries, attract new ones, and expand Welsh trade at home and overseas.

Hugh Kendall, a former test pilot of Handley-Page Ltd, who was subsequently responsible for the design of the SK–1 Light Aircraft, has joined the technical department of Shell-Mex and BP Ltd. His new duties involve technical liaison with the British aircraft industry and airline operators.

Monsanto Chemicals Ltd announce that, to meet the organizational requirements of the company's development programme, the following appointments were made recently: **W. M. Thompson,** director of purchases, to be sales director. **J. S. Brough,** chief engineer, to be general manager of production. **J. S. Hunter,** sales controller, to be general manager of development. **W. E. Hamer,** manager of research department, to be general research manager. **J. M. Kershaw,** project manager, to be chief engineer. **D. C. M. Salt,** sales controller, to be general manager of sales. **G. Dodd,** director and general manager of Monsanto Plastics Ltd, to be controller of purchases, Monsanto Chemicals Ltd. **E. L. Pixton,** a sales controller of Monsanto Chemicals Ltd and a director of Monsanto Plastics Ltd, will, until further notice, be seconded to devote the whole of his time to promoting the present and future marketing interests of Monsanto Plastics Ltd. The appointment is also announced of **O. W. Murray**, chief construction engineer, to be deputy chief engineer.

E. V. Corps, exploration manager of Pakistan Petroleum Ltd, retired on 11 September after 26 years of oil industry service in the East.

Mr Corps, who has also been manager of PPL for a time, joined Burmah Oil in 1930 as a geologist, being posted first to Yenangyaung, Burma, and later to the Digboi oilfield in Assam. After 10 years of work in the geological department at Digboi he was appointed acting senior geologist, Burma, to be re-assigned shortly thereafter to Digboi as senior development geologist of the Assam Oil Company. He spent a year in Pakistan as development geologist of The Burmah Oil Company (Pakistan Concessions) Ltd before returning to Digboi as acting senior geologist for the Burmah Oil Group from 1950 to 1953. On return from leave at the end of 1953 he was appointed PPL's exploration manager.

Dr A. W. Pearce, A.M.Inst.Pet., has been appointed General Manager of Refining at Esso's Head Office in London. This appointment newly created on 1 September means that he is now responsible for co-ordinating all the refining and manufacturing activities of Esso in the U.K.

Dr Pearce, who is 35 years of age, joined the Company in 1945 as technical assistant at the old Fawley refinery. As assistant manager, technical service department in 1947, he was closely concerned with the design and construction of the new refinery, and in 1950 he was appointed process superintendent, and was responsible for training all its operating personnel. He was also in charge of the start up of all new equipment when the new refinery came on stream in 1951. In 1954, he was appointed assistant refinery manager.

John W. Gendron of Tidewater Oil Company has been elected president of Iricon Agency Ltd. succeeding R. S. Stewart, vice-president of the Standard Oil Company (Ohio).

Iricon is the organization established to represent the 5 per cent interest in the Iranian Consortium held by American Independent Oil Company, Atlantic Refining Company, Getty Oil Company, Hancock Oil Company, Richfield Oil Corporation, San Jacinto Petroleum Corporation, and Signal Oil and Gas Company, as well as Standard of Ohio and Tidewater.

Other newly elected officers include **L. C. Bergquist** of Iricon's London Office (vice-president); **David E. Day** of Richfield (vice-president); **J. J. Shrewsbury** of Hancock (treasurer), **S. K. McCauley** of Atlantic (assistant treasurer); **Raymond W. Ickes** of American Independent Oil Company (assistant secretary).

Benjamin Tyran of American Independent and **John K. Schemmer** of San Jacinto were elected to the Iricon Board of Directors.

J. W. Ross has been appointed naval architect in the engineering department of the BP Tanker Co Ltd, where he has been employed since 1939. After leaving Durham University, Mr Ross served in the designing office of Swan Hunter and Wigham Richardson Ltd and subsequently with other leading shipbuilders.

Marling J. Ankeny recently took his oath of office as 10th director of the U.S. Bureau of Mines. Mr Ankeny thus returns to the agency he served for 24 years until his resignation in 1952, when he received the Department's Honour Award for Meritorious Service, to become safety director for the Bituminous Coal Operators' Association.

Survey of India

Developing the Mineral Wealth of India

Writing in *The Financial Times Survey of India*, a Special Correspondent says (13 August) that capital expenditure on the development of Indian mineral resources over the next few years is expected to reach about £55,250,000 (Rs. 750m.). The funds available will be used to implement plans already drawn up during the last two years of the first five-year plan to accelerate exploration programmes and to expand existing production facilities. In preparation for the forthcoming frontal onslaught on the country's wasting assets the staffs of the Geological Survey of India and the India Bureau of Mines have been substantially increased and academic institutions have been placed on a firmer footing, to help effect the programme.

Of all the recent work undertaken by the Geological Survey of India (see also *IP Journal* Abstract *670*, 1956) the most important is, perhaps, the systematic oil survey being undertaken in Assam and Bengal.

These surveys are part of the Government's plan to enter into the oil industry, which, at present, is very largely in the hands of foreign interests. In addition to a sum of £7,250,000 (Rs. 110m.) which the Government is making available to private companies already engaged in the industry, it is planned to expend £21,750,000 (Rs. 290m.) for the exploitation of oil in four areas under its own auspices.

The most important of the Government's exploration schemes are as follows:—

(1) Jaisalmer, Rajasthan, at an expenditure of about £6 million over the next five years.

(2) Uttar Pradesh and Punjab, in three stages, at an estimated cost of £1·7 million.

(3) Sundarabans, West Bengal, where the Standard Vacuum Oil Company is also exploring.

(4) Saurarhtra, at a cost of approximately £5·6 million.

In regard to the schemes involving collaboration with private companies ahead in the field, the Correspondent states that the first venture is the joint scheme with the Assam Oil Company which has been carrying out aerial and aeromagnetic surveys as well as geophysical surveys for some time. The Company is now in the process of drilling test wells at Hugrijan and Moran. The provision of £1·7 million (Rs. 22·5m.) is said to have been allocated for continuing co-operation with the Standard Vacuum Oil Company and a further £3¾ million (Rs. 50m.) to have been set aside for similar co-operation with other private agencies which may enter the field.

India's Rapidly Growing Demand for Oil Products

In the same issue of *The Financial Times Survey of India*, a Special Correspondent states that India is no exception to the rapid world-wide growth of the demand for oil. Since India is a country of nearly 600,000 villages with 70 per cent of its huge population (at present estimated at some 350 million people) engaged in working on the land, it is not surprising that the primary requirement is for kerosine. Kerosine accounts for nearly one-third of total demand and the consumption per head of all products, at a little over 3 gallons per year, is very low—in the U.K. the consumption per head is around 150 gallons per year and in the U.S.A. nearly 600 gallons.

India's next greatest demand is for gasoline and furnace oil but both these commodities are rapidly being overhauled by automotive diesel, mainly for road vehicles. Complementary to the growth of demand for automotive fuel is that of bitumen, a product which is assuming much greater importance as the sadly inadequate road mileage increases.

The main companies engaged in meeting the demand for petroleum are Burmah-Shell, Standard-Vacuum, and Caltex. In Assam, the Assam Oil Company both markets and produces oil.

It is stated that a considerable saving in foreign exchange has been achieved as a result of adopting the post-war trend of locating refineries in the areas of consumption. The latest example of this is the 700,000 tons-per-year refinery which Caltex are building at Vishakapatnam, on the east coast.

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BSI PETROLEUM STANDARDS

In its report for the year ended 31 March 1956, the BSI states that as a result of discussions with the Institute of Petroleum, five IP methods of test have been drafted as BS specifications and issued for comment. A further two methods for knock-rating of motor fuel have been published as British Standards.

BS 2626 for refrigerator lubricating oils was published during the year and provides for oils in four viscosity ranges. The two fuel oil specifications, BS 209 for fuel oils for oil engines and BS 742 for fuel oils for burners, are under revision and will be shortly submitted for approval for publication as one standard.

Two standards for locomotive lubricating greases are under preparation, one for locomotive motions and the other for ball and roller bearing axle boxes. The revised standard for steam turbine oils was also issued and at the end of the year work was in hand on a revision of the classification of lubricating oils and on a standard for penetrating oils.

Petroleum Equipment

During 1955-56, Part 1 of BS 2654 for vertical welded storage tanks was issued, and dealt with design and fabrication. Part 2, dealing with site erection welding and inspection, is being prepared and will be circulated for comment during 1956. At the end of the year a considerable amount of work was in hand in regard to petroleum equipment.

International Co-operation

During a meeting of ISO/TC28 on petroleum products the ASTM/IP petroleum measurement tables were accepted as a draft ISO recommendation together with the two methods of determining the knock-rating of motor fuels. Further methods of testing petroleum products are under consideration by ISO, including the determination of viscosity.

An artificial ageing test for insulating oils was discussed at a meeting of IEC/TC10 on insulating oils, and research on this test is proceeding. The United Kingdom view is that it is desirable to reduce the testing time to a maximum of 48 hours.

New IP Publications

Essential Factors in the Future Development of the Oil Industry

The rate of increase of the world's energy requirements will continue for many years to come. Consequently, there will be a corresponding demand for increased supplies of fuel. Until nuclear energy can satisfy a substantial amount of this demand petroleum fuels must be relied on to fill the gap.

Exactly how this is to be achieved was the theme of the Institute of Petroleum's Summer Meeting held at Torquay in June, and now recorded in a handsomely bound volume of 176 pages. Edited by George Sell, the full list of subjects and authors is as follows:

Introduction
The World Energy Outlook. By G. P. Glass and J. H. D. Page
The Outlook for Atomic Energy. By C. M. Nicholls
The Oil Demand Outlook. By C. P. Dalton and J. S. Senior
Oil Resources in the Next Half Century. By D. C. Ion
The Changing Pattern of World Oil Movements. By W. Jamieson
Recent Developments in Oil Refining Techniques. By A. L. Down
Oil's Future as a Source of Chemicals. By W. d'Leny
Financial Factors in Oil Development. By P. M. de Veulle and F. G. Thackeray

Each paper is followed by a full report of the discussion which took place at the meeting. The price of the book is 40s., post free, and copies may be obtained from the Institute of Petroleum, 26 Portland Place, London, W.1.

Electrical Code

Since the second edition of the Electrical Code was published in 1950, a committee of the Institute of Petroleum has had its provisions under continual review in the light of comments received as a result of the world-wide application of the Code. A number of important revisions have been found necessary and a revised third edition is now available. One of the most important of the revisions is in regard to the classifications of "remotely dangerous location" and "remotely dangerous area."

When the 1950 edition was published these classifications were applied exclusively to oilfields. Experience gained throughout the world has shown that these classifications can be considered as applicable to refineries and to market installations. This extension of the applicability of the two classifications has necessitated additions to the rules (series 100) and corresponding changes in other parts of the Code. The revised third edition is in looseleaf form for insertion in the covers supplied with the previous edition and copies may be obtained from the Institute, price 17s. 6d., post free. Those wishing to have one of the special covers can obtain this from the Institute, the price being 15s. 6d.

Other Publications

"Oil and the Future"

The interest created by a series of three articles which appeared in the *Esso Magazine* (1955-56 issues), on the subject of providing adequate supplies of energy to meet a sharply rising demand, has led to the publication of these articles in booklet form, under the title "Oil and the Future".

A brief introduction to the booklet summarizes its themes —what it will mean in terms of volume of products and the financial and other problems that will face the oil companies in the U.K. if they are to fill the gap between the nation's actual energy requirements over the next 25 years, and the available supplies of coal and nuclear power.

The booklet also stresses the fact that coal, nuclear energy, hydro-electricity, and oil all have their part to play in Britain's progress towards prosperity. No one source of energy will totally replace another. Nor is any one source capable any longer of doing the whole job single-handed.

Copies of the booklet are available free on request to Esso Petroleum Co Ltd, 36 Queen Anne's Gate, London, S.W.1.

Dechema Monographs

The 21 plenary lectures that were delivered at the First Congress of the European Federation for Chemical Engineering, at the Annual Congress and General Meeting of the Dechema for 1955, and at the Achema Congress for 1955 are contained in the "Dechema-Monograph" series, Vol. 26. Of particular interest are O. Samuelson's contribution entitled "Adsorption with Organic Ion Exchange", the articles on high-pressure vessels, heat exchangers, filtration methods and equipment, production of hydrosulphite, irregular electron patterns, and catalysis.

Significance of ASTM Tests

The eleven chapters of this third edition of the ASTM booklet on "Significance of ASTM Tests for Petroleum Products" contains much information of value to those who require to have some knowledge of the meaning of an item of test data without necessarily knowing the details of the test procedure.

Main headings are: (1) Sampling; (2) Measurement and calculation of volume; (3) Volatility; (4) Combustion; (5) Oxidation; (6) Flow and solidification; (7) Corrosion; (8) Other physical characteristics and tests; (9) Chemical analysis and tests; (10) Hydrocarbon types; (11) Butadiene analysis.

Each chapter gives information on the method of test and the apparatus employed. The significance of the result of the test is discussed in relation to the particular product and the purpose for which it is to be used.

Containing 134 pages, the price of the book is $2.50 in heavy paper cover, or $3.75 cloth-bound, and it is obtainable from the ASTM, 1916 Race Street, Philadelphia, 3, Pa, U.S.A.

Ultrasonic Thickness Measurement

By **J. CARMICHAEL***

The cost of corrosion to the chemical industry lies not so much in the value of replacement parts as in the loss of production incurred in shutting plant down to carry out periodic corrosion checks. The ultrasonic thickness gauge, which can measure corrosion effects without interfering with production, is therefore of the utmost economic importance.

The more general availability of simple and cheap transducers has greatly increased the application of ultrasonics, since such waves can now be generated economically by equipment of modest size. These applications include the settling of flue dusts, the mixing of liquids, the soldering of aluminium, the measurement of wall thickness, and many others. The possibility of using ultrasonics for measurements is perhaps of greatest interest to the oil and allied industries, as this method is well suited to their particular needs.

The outstanding advantage of ultrasonic measurement is that the wall thickness of a vessel or large plate can be measured even when only one side is accessible. This means that measurements can be made on chemical plant from the outside even while the reaction is proceeding inside it. Moreover, measurements, even in awkward and inaccessible places, can be made by unskilled labour.

Ultrasonic thickness measurements take two forms. The first of these works on the same general principle as radar: an ultrasonic signal is generated in a transducer, comprising a small piezo-electric crystal, and is fed into the accessible side of the wall to be measured. In all practical cases the signal will then be reflected, at least in part, from the far side of the wall, since this represents a point of increasing acoustic impedance. By displaying, on a cathode ray oscilloscope, the instant at which the ultrasonic signal is fed into the object and the instant at which the signal leaves the object on its return, it is possible to obtain a measurement of wall thickness if the speed of the waves in the body is known. In Fig 1 the principle of this method of measurement is illustrated diagrammatically.

The necessity for a cathode ray tube places certain restrictions on the application of this method. In general, such a device is not conveniently worked from batteries so that it is restricted to measurements at points where a source of mains electricity is available. For this reason, and because of the relatively large size and fragility of the tube, such

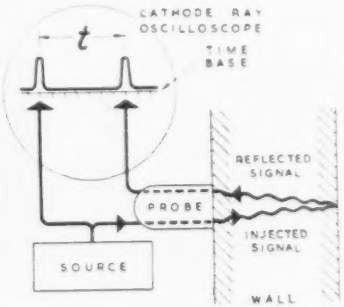

Fig. 1 If the velocity V *of sound in the material measured is known, the time taken by the signal to traverse the wall twice is measured and wall thickness* $= \frac{1}{2} \times t \times V$.

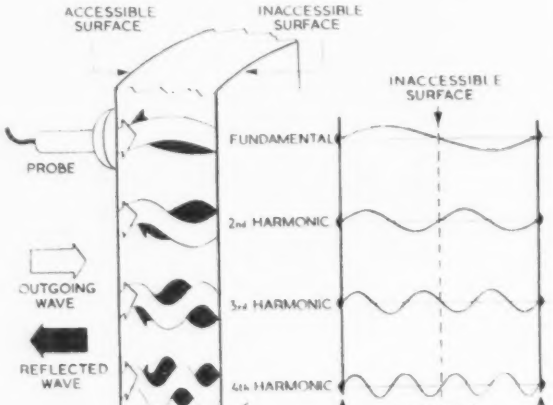

Fig 2. How wall thickness is measured by reflected waves at the fundamental frequency or at its harmonics. At the right the wall thickness is opened out to separate outgoing and reflected signals.

instruments may be "transportable", but are not truly portable. This difficulty is overcome by the second method of ultrasonic measurement. Known as the "resonance" method, this requires no cathode ray tube and can readily be powered by small dry batteries housed in the base of the instrument. When in the working condition, a typical instrument of this type, complete with all the necessary electronic circuits and batteries, is housed in a robust metal case measuring $12\frac{1}{4} \cdot 8\frac{1}{4} \cdot 7$ inches. It weighs only 20 lb complete with batteries and is carried by the operator by means of a webbing harness of the type shown in Fig 3.

In this type of instrument, an ultrasonic signal is again generated by a crystal transducer and is fed into the surface of the component being measured. The same crystal is also used to pick up the returning signal. A feature of this type of instrument is that the frequency, and hence the wavelength of the injected signal, can be varied between fairly wide limits by means of a control knob and a calibrated dial.

As with many other quantities, the outgoing and incoming signals are "additive", this term covering both addition and subtraction according to the relative phase of the two signals. In the limiting case, when the distance travelled by the signal is a whole multiple of the wavelength, the incoming and outgoing signals will be in phase and will strongly reinforce each other. In this resonant condition there will be a sharp increase in the combined signal. This principle can be seen clearly from Fig 2, which indicates the varying effect for the

*Dawe Instruments Ltd, London W.5.

different wavelengths forming sub-multiples of the path length.

The occurrence of a maximum signal can readily be determined by the operator by the increase in level of an audible noise in his headphones or on a meter provided for this purpose. The path length of the signal will now be a multiple of the wavelength of the signal. Since the wall thickness (t) to be measured is exactly half the distance travelled by the signal in the material, we get the following simple formula:—

$$2t = n\lambda$$

when n is an integer and λ is the wavelength of the signal.

If we know the approximate thickness of the wall being measured, it is a simple matter to obtain the exact thickness if we know the value of λ. For instance, we may be measuring the wall of a Hortonsphere made from $\frac{1}{2}$-inch plate and obtain a signal rising to a maximum and decreasing to either side of a wavelength of 0·119 inch. The true thickness is then clearly $4 \times 0{\cdot}119$ or 0·476 inch, thus showing a nominal wear of 0·024 inch.

In practice, however, one seldom knows the true thickness and has to avoid this difficulty in another way. One method of doing this is to find two adjacent maxima at wavelengths of, say, λ_n and λ_{n+1}.

$$t = (n \,.\, \lambda_n)/2 \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

and

$$t = (n+1) \,.\, (\lambda_{n+1})/2 \quad \ldots \quad \ldots \quad (2)$$

by eliminating n,

$$t = (\lambda_n \,.\, \lambda_{n+1})/2(\lambda_n - \lambda_{n+1}) \quad \ldots \quad (3)$$

Another way is to continue to pass through maxima until the operator finally obtains the longest wavelength above which there is no further maximum. This wavelength (λ_1) is the fundamental for this particular wall thickness and

$$t = (\lambda_1/2) \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Unfortunately, the fundamental wavelength may not lie within the range of the instrument for many wall thicknesses. The thickness gauge shown in use in the illustrations has a range in steel of from $\frac{1}{16}$ up to 12 inches, but the fundamental cannot be used for thicknesses above 0·116 inch in steel since the signal frequency can only be adjusted between 0·65 and 2·0 Mc/s. Above this figure, it is necessary to use the more general expression stated in equation (3) and to resort to the use of harmonics.

Fig 3. The operator holds the crystal transducer in contact with the surface of the body of a petrol tanker in course of construction, in order to check that the dished end is at the specified thickness.

Fig 4. A magnetic fixture holds the crystal probe of the thickness gauge in close contact with a magnetic surface, so that the operator can employ one hand to steady himself and the other to operate the gauge.

Fig 5. This section from a spirit line shows the localized effect of pitting which is easily missed by drilling or "tapping" but is readily located by ultrasonic gauging. (Courtesy Shell Petroleum Co Ltd.)

So far, for clarity, it has been assumed that the wavelength of the signal is the main parameter. This is, in fact, not so: it is really the frequency of the signal which is set. By applying a signal of the same frequency to, say, steel and copper a different wavelength in the two metals will be obtained. It is, however, true that for a homogeneous material the frequency and wavelength are inversely proportional to one another, the product being the speed of ultrasonic waves in the material, so that $f \times \lambda =$ velocity (V). The wavelength for a given frequency will therefore be the same for all similar substances.

If V/f_n and V/f_{n+1} is substituted in place of λ_n and λ_{n+1} in equation (3), the simpler expression

$$t = V/2\,(f_{n+1} - f_n) \quad \ldots \quad \ldots \quad (5)$$

is obtained. In an actual instrument of this type, such as that shown in Fig 3, the thickness can be established directly by a suitable setting of the scale. This scale is initially set by a trial measurement on a component of known thickness, or to a constant derived from the known speed of ultrasonic waves in the material being measured. Such waves, for instance, travel 19,300 ft/sec in steel and this figure is virtually unaltered by heat-treatment, grain size, cold working, and so on. A similar state of affairs exists for most reasonably pure metals, including nickel, aluminium, copper, titanium, and some plastics. It is this fact which renders possible the measurement of thickness by means of ultrasonic waves.

The complete equipment required for such measurements is shown in Fig 3. The robust metal case contains all the necessary electronic circuits and dry batteries. Into a socket on this case is plugged a pair of headphones for detecting the condition of resonance.

The operator requires one hand to operate the frequency control on the instrument while the other hand normally holds the crystal probe to the surface of the wall whose

thickness is being measured. In awkward or high locations it may be inconvenient to do this, particularly if the operator requires one hand to steady himself in a high wind. In such cases, the probe can be held in contact with the surface by means of a simple magnet adaptor, in which a strap between two magnets supports the probe (see Fig 4).

If the surface of the wall being measured is reasonably smooth, the crystal probe can be applied direct, a thin film of oil, grease, or glycerine being used to give a good acoustic coupling between the crystal and the work. If the surface is rough or is covered with rust, paint, or scale, it may be necessary to prepare a suitable point for applying the probe, by filing or grinding.

As far as coatings on the far, inaccessible side are concerned, these are not recorded as part of the wall thickness, since the signal is reflected by the interface between the good metal and the rust, paint, or other material. Where such coatings adhere very closely, the signal may be partly absorbed and the response become a little weaker, but the accuracy of the gauge is not affected.

To take a thickness measurement on this type of instrument requires only about half a minute, including the manipulation of the conversion scale and the noting of the readings. The factors limiting the number of readings which can be taken in an hour or day are first, the time taken by the operator to move from point to point and, secondly, the time required to gain access to the wall to be measured. The first of these factors can be minimized by careful planning of the itinerary and the second by such precautions as leaving detachable panels in lagging at suitable points.

Although this type of ultrasonic instrument is valuable during manufacture, its main application is undoubtedly to obtain the greatest possible economic life from chemical plant. With present methods, it is difficult to keep track of the wear on the inside of plant without stopping the reaction, which may well be a costly business. With an ultrasonic thickness gauge it is possible to keep a continuous record of wear at all the salient points of the plant without interfering with its operation in any way. By comparing the values for wear obtained ultrasonically against the original allowances, plant can be replaced in good time. Plant failure can thus be avoided without need for the premature replacement of parts, which is highly uneconomical.

The gauge also offers a possible means for obtaining long-term tests on the corrosion resistance of clad plate under operating conditions, so that a complete and scientific evaluation of this material can be made.

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ASSAM OIL SEARCH

The Assam Oil Company announces from Digboi that Well No. 15 in Tengakhat, Hugrijan prospecting licence area, has been completed without striking oil.

Since mid-1953 eighteen wells have been completed in the alluvial areas of the Brahmaputra Valley of Upper Assam. Among these, four wells, including this Tengakhat well, failed to find oil.

Drilling operations at the well have ceased and the equipment will be removed to Langkasi, a new location in the Hugrijan area, as soon as the hole has been plugged with cement.

The effect of this disappointing result is that the extent of the oil-bearing area to the North-West of the original discovery well at Nahorkatiya is less than was expected. Meanwhile Well No. 19, situated on the north of the discovery well, is drilling ahead. Work on other new locations is also in progress.

Arrangements to test Well No. 1 at Moran, a tea area between Sibsagar and Lakhimpur Sub-divisions, are in hand. This is the deepest well drilled in this sub-continent, being 13,739 feet (nearly 2½ miles) deep.

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SURVEY OF PIPELINE THROUGH TURKEY

In response to inquiries about reports that an Iraq Petroleum Company survey party is engaged in surveying a pipeline route through Turkey, a Company spokesman confirmed that a preliminary reconnaissance is being carried out.

Long before the Suez crisis the possibility of a pipeline route through Turkey was under serious consideration by the Company. The Turkish Government was therefore approached and its permission was obtained for the making of a preliminary survey of a possible pipeline route. A technical survey party, the spokesman explained, is now conducting this reconnaissance as a basis for further consideration of the project which is part of a plan for the long-term development of Iraq oil production.

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DEVELOPMENT OF AUTOMATIC CONTROL IN OIL REFINING

After outlining the concept of automation as practised in the petroleum industry for many years, a Special Correspondent writing in *Electronics and Automation*, a *Financial Times* survey (23 July), says that the automatic control on a refinery unit is set solely on operating conditions and not on what it is really desired to control, namely product quality. He maintains that this is done at present by carrying samples to the laboratory where they are analysed by, in some cases, quite time-consuming methods, the results being passed back to the plant when the necessary adjustments are made to the operating variables.

It is maintained that the reason for this is simple, namely that the necessary instruments do not yet exist or, if they exist, as they do in some cases, have not been yet brought to a sufficiently high standard of reliability for plant control. Further, it is contended that if such instruments could be designed which would give rapid product quality control on the units, then much more rapid adjustment of plant conditions would be possible, with increased efficiency of operation and saving of manpower.

Continuing, the correspondent maintains that the instrument manufacturers have made great strides in the development of rapid methods of laboratory analysis, *e.g.* infra-red spectrometry, mass spectrometry, and gas chromatography, all of which point the way for possible methods of control. A certain amount has, of course, already been done in this field but it only touches the fringe of the problem because of the diversity of product quality analyses which ideally would be required. At the present time over a hundred tests are carried out on the wide range of products made in the petroleum refinery.

(*Continued on page* 280)

Trade Literature, etc.

Three New Valves

Hindle-Hamer have recently issued a data book and price list of their blind valves, visible wedge valves, and gate valves. Copies are obtainable from Joshua Hindle and Sons Ltd, Hindle House, Neville Street, Leeds.

Defeating Inflation

Provided that there are no substantial advances in wages or raw materials Taylor-Short & Mason Ltd, London, E.17, announce that they will maintain the present prices of their process control instruments for a period of 12 months from 1 September.

New Range of Lift Trucks

A new range of pneumatic-type fork-lift trucks has recently been introduced by the Hyster Company. Powered by a powerful water-cooled engine, the range includes 3000-, 4000-, and 5000-lb capacity models. Optional features include power steering, "Hystematic" fluid torque converter drive, LP-gas installation, dual front wheels, overhead guard, and "free lift."

Needle Metallic Recuperators

An attractive illustrated brochure describing several types of recuperator has been issued recently by Newton, Chambers & Co Ltd of Thorncliffe, nr Sheffield. Among the advantages claimed for preheated air or gas are the following:—

(1) Direct fuel savings of up to 30 per cent.

(2) Better mixing and combustion and the possibility of obtaining the required furnace temperature with leaner fuels.

The brochure also gives details of results obtained from some typical installations and illustrates various recuperator layouts.

Brighton Garage Opened

Many well-known local personalities and members of the motor trade attended the opening ceremony, on 2 August, of Robin Hood Garage at Patcham, Brighton. J. N. Lister, manager of Mobil Oil Company's Southern Automotive Division, declared the garage open on behalf of the proprietor, C. E. Wise.

The site, which is on the London—Brighton Road, is about 3 miles from the sea. The new building incorporates a salesroom, with a full range of accessories and spares, modern washrooms, and stores.

Robin Hood Garage viewed from the London-Brighton Road.

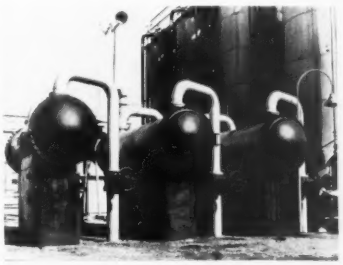
Liquid Separator-Filters

Details of the range of Fram two-stage filters, which ensure water-free fuel for aircraft, are contained in a brochure and maintenance manual which are supplied in a useful folder.

The first stage (filtering) consists of passing fuel through coalescor cartridges—these remove solid contaminant down to 5 micron particle size.

The second stage (separating) consists of passing the fuel through separator cartridges which permit passage of the hydrocarbon but prohibit water. The water falls away into a sump and can be drained off, either manually or automatically.

Three typical two-stage aircraft fuel filters.



Further details and the complete folder may be obtained from Simmonds Aerocessories Ltd, Treforest, Pontypridd, Glamorgan.

Repeat Order

G. & J. Weir announce that they have received a fifth order for a set of their sea water evaporating and distilling equipment.

Remote Controls

As a result of the installation of new plant at its Huddersfield factory, the Compoflex Company has now extended its range of metallic fibres to include not only the manufacture of light and heavy cable transmissions of the push-pull and spring return types but also speedometer and tachometer cables.

Details of the new products are given in a brochure, entitled "Metallic Flexibles", obtainable from The Compoflex Co Ltd, 23-25 Northumberland Avenue, London, W.C.2.

Caught Red-handed

The importance of automatic, fault-proof detection of fire in the petroleum industry is too well known to need further emphasis here. However, detection equipment may not be so widely known. *Caught Red-handed* is the

title of an attractive and informative brochure published recently by the Pyrene Co Ltd who claim that effective operation of the company's equipment is ensured by a periodical maintenance service which provides for the testing of each control unit and for repair or replacement, where necessary, at a moderate and inclusive charge.

New Factory Nears Completion

A large office block and a new factory which will eventually extend to 240,000 sq ft nears completion at Redhill. This will be occupied by Foxboro-Yoxall Ltd, a firm which specializes in the manufacture of industrial control instruments, such as controllers, recorders, and indicators for temperature, pressure, liquid level, flow, etc.

The firm has devoted much thought to the employees' recreational pursuits and provision has been made for a sports field large enough for football and cricket pitches, tennis courts, and a sports pavilion.

Forthcoming Meetings

THE INSTITUTE

(At 26 Portland Place, London, W.1, 5.30 p.m.—tea 5 p.m.)

Symposium on Digital Computers in the Petroleum Industry. 7 November

IP FAWLEY BRANCH

(At Esso (Fawley) Recreation Club, Holbury, 7.30 p.m.)

Chemicals from Petroleum. Dr R. F. Goldstein, B.Sc., Ph.D., F.R.I.C. 12 October

The Trade Unions and Automation. H. R. Nicholas, T.G.W.U. 16 November

IP LONDON BRANCH

(At 26 Portland Place, London, W.1, 6.0 p.m.—tea 5.30 p.m.)

Petroleum Chemicals and their Application. D. P. Dodgson, Ph.D., M.Sc., F.R.I.C. 24 October

An Introduction to Electronic Accounting in the Petroleum Industry. K. T. Woodard. 20 November

IP NORTHERN BRANCH

(At the Engineers' Club, Albert Square, Manchester 2, 6.30 p.m.)

Additives for Lubricants. G. H. Thornley. 16 October

Annual Dinner-Dance, Midland Hotel, Manchester. 9 November

Diesel Electric Traction. D. C. H. Mathews. 20 November

IP SOUTH-EASTERN BRANCH

(At Gravesend, 7.45 p.m.)

Practical Application of Bitumen in the Oil Industry. Mr Wheedon. 15 October

Annual Ball, Tudor House, Bearsted. 19 October

(At King's Head Hotel, Rochester, 7.45 p.m.)

Automation in Refineries. D. C. Nutting. 6 November

IP SOUTH WALES BRANCH

(At the Training Centre, BP Refinery (Llandarcy) Limited, 5.30 p.m.)

Joint Meeting with the Institute of Fuel

Petroleum Fuels for Domestic Heating and Lighting. G. F. J. Murray, M.I.C.E., M.I.Chem.E., M.Inst.F., A.M.Inst.H. & V.Eng. and D. G. Tompkins, B.Sc., A.R.I.C. 2 November

IP STANLOW BRANCH

(At Grosvenor Hotel, Chester, 7.30 p.m.)

The Place of the Chemical Engineer in the Petroleum Refining Industry. H. E. F. Pracy, B.A., M.I.Chem.E., F.Inst.Pet. 17 October

Engine Symposium: Spark Ignition Engines. P. W. Bedale, B.A., A.M.I.Mech.E.

Compression Ignition Engines. B. J. Donovan, A.R.I.C. 21 November

(*Continued from page* 278)

Among suggestions made in the article are: —

(1) The use of automatic instruments for viscosity control of products.

(2) Plant control for the removal of sulphur from products, such as kerosine and gas oil, by extraction and hydrogenation processes.

(3) The use of electronic computing equipment in order to establish whether a catalytic cracking unit is running at a level of optimum profitability. Further, to integrate such calculations with direct control of operating variables on the unit.

Finally, it is stated that although the day is far distant when a complete refinery can be operated from a single control room, there is one development ahead which points in this direction, namely the use of automatic gauging of tankage being transmitted to a central point. Such equipment is already on the market and should have wide application in the future.

MIDDLE EAST PRODUCTION

	July	*Jan. to July*
	Tons	
Iraq Petroleum Co Ltd	2,238,093	14,154,013
Basrah Petroleum Co Ltd ...	759,361	4,916,420
Mosul Petroleum Co Ltd ...	111,686	740,274
Iraanse Aardolie Exploratie en Productie Mij*	2,441,000	14,581,000
Qatar Petroleum Co Ltd	518,126	3,475,227
Kuwait Oil Co Ltd	5,046,645	33,857,395

*The refinery throughput at Abadan of the Iraanse Aardolie Raffinage Mij for July was 987,000 tons, the total for January to July being 5,942,000 tons.

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SITUATIONS VACANT

Fuel Technologists. Graduates with a degree in Fuel Technology or in Chemistry, Chemical Engineering or Engineering, with a diploma in Fuel Technology, are invited to apply for posts concerned with development work on furnace operation and temperature measurement on high temperature furnaces, both gas and oil fired. In the Glass Industry, which is a major fuel consumer, interesting and rewarding jobs are available in Works at St. Helens (Lancashire) and Doncaster (Yorkshire).

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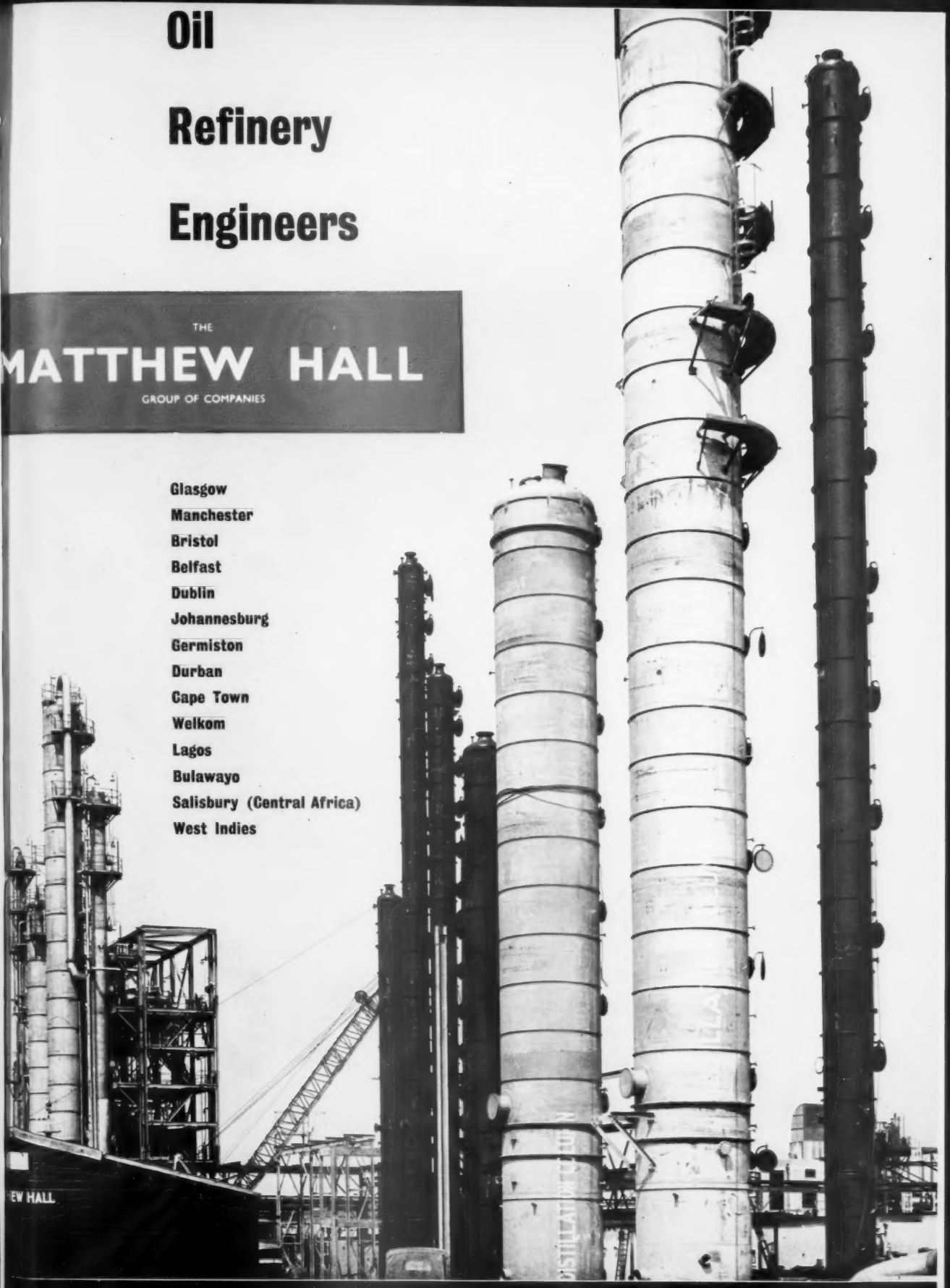

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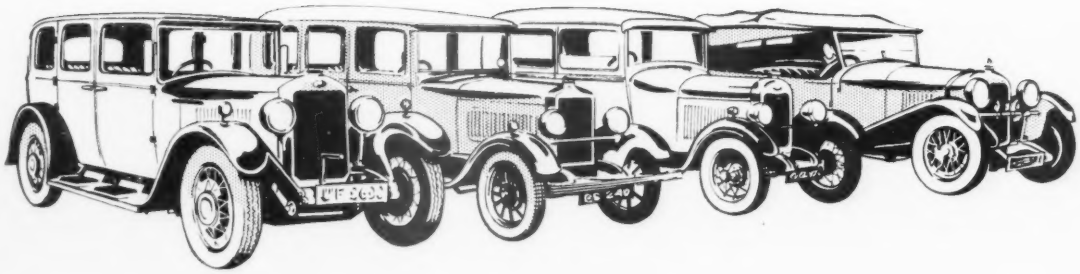

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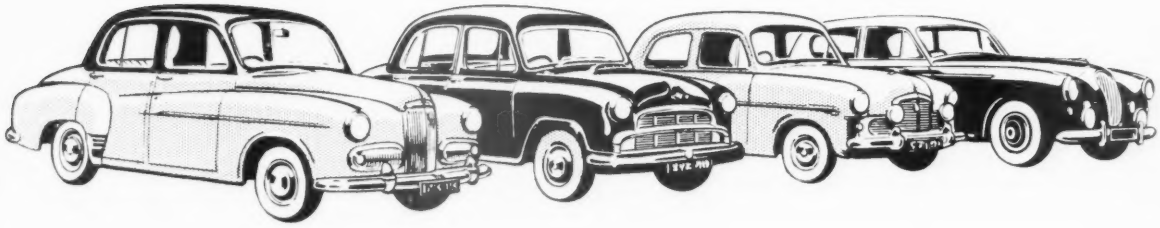

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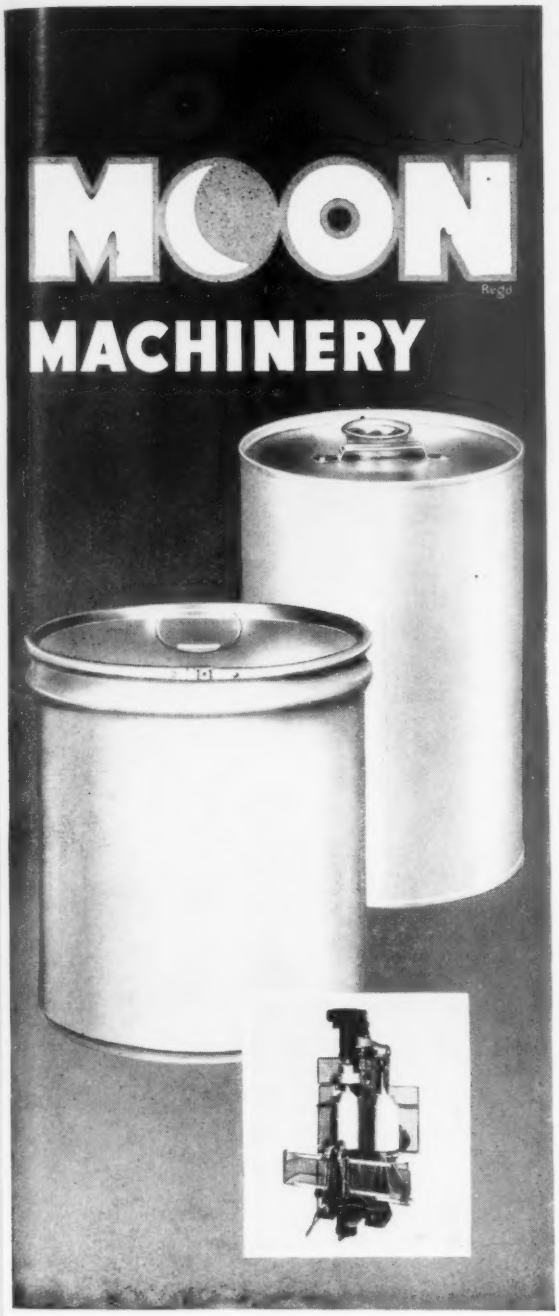

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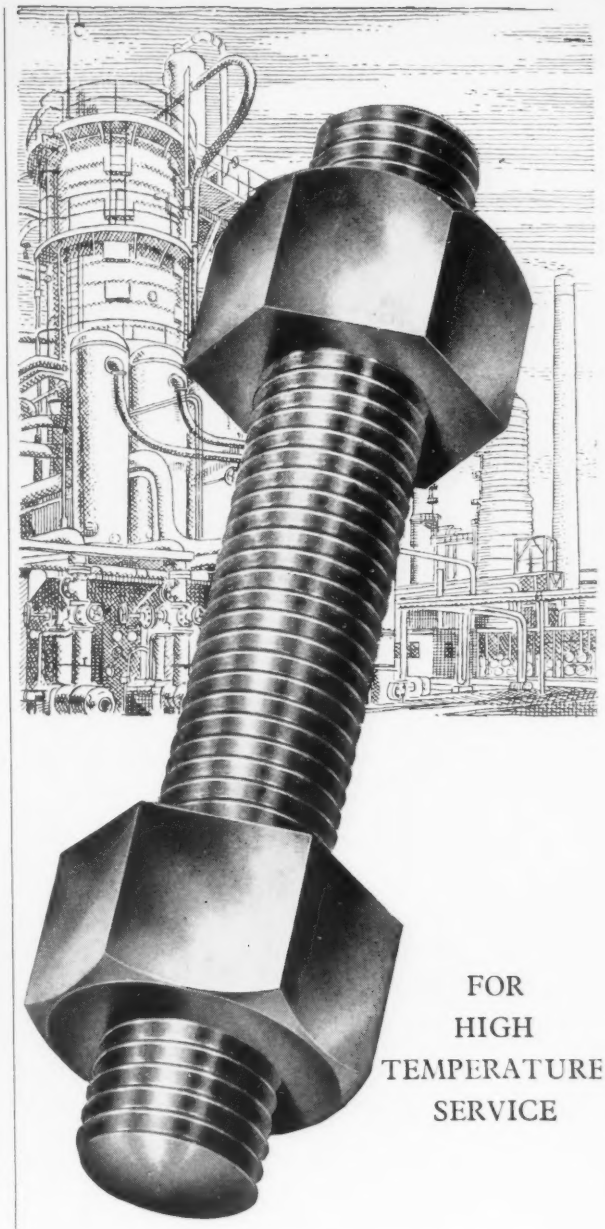

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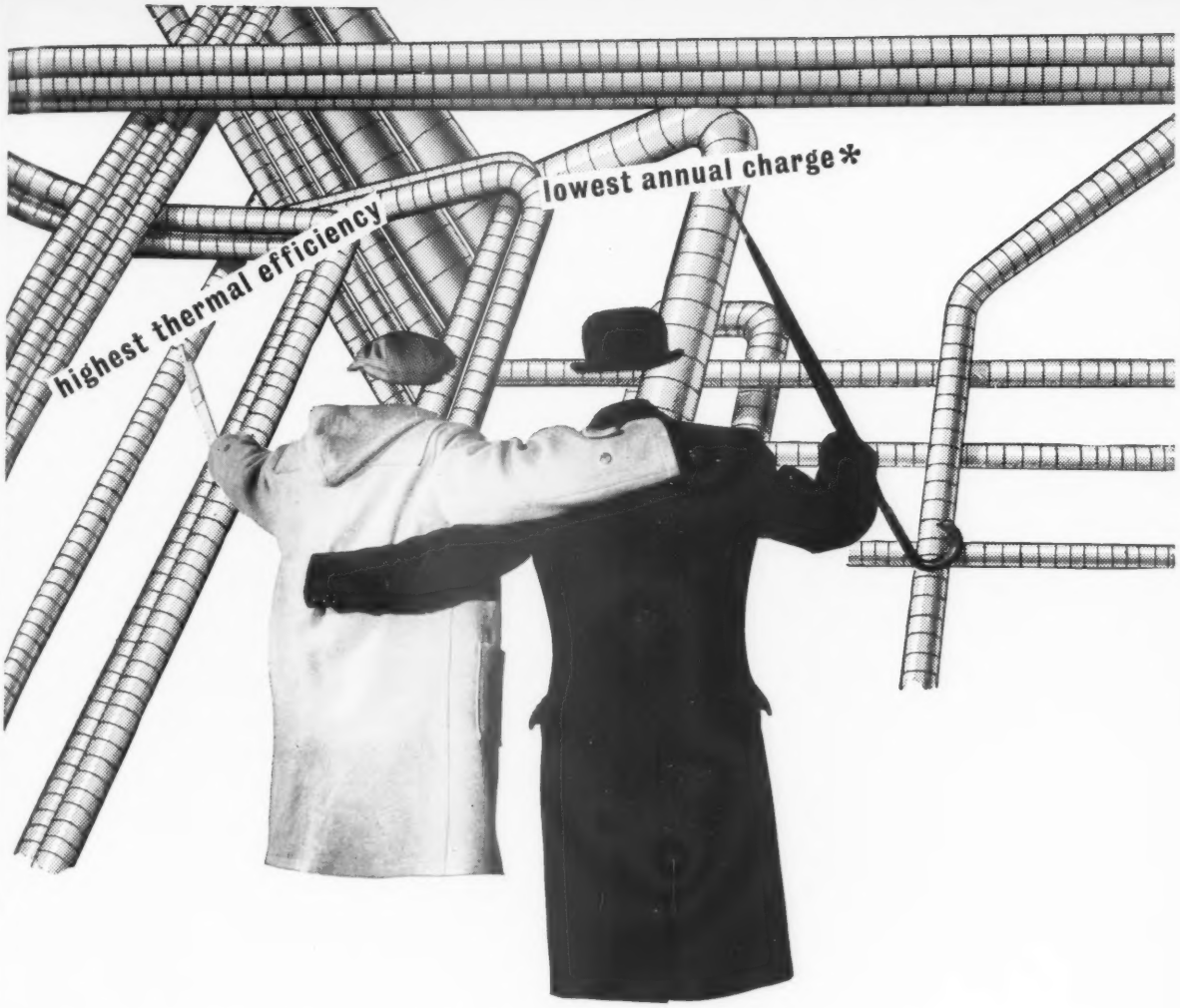

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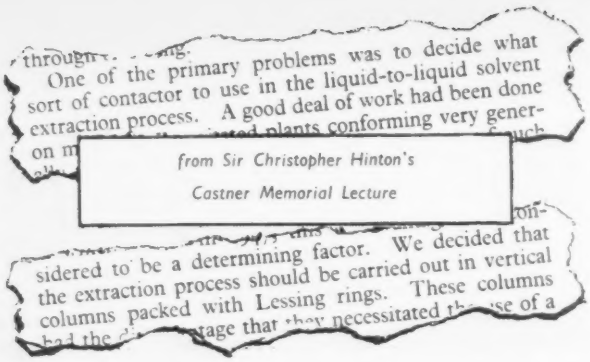
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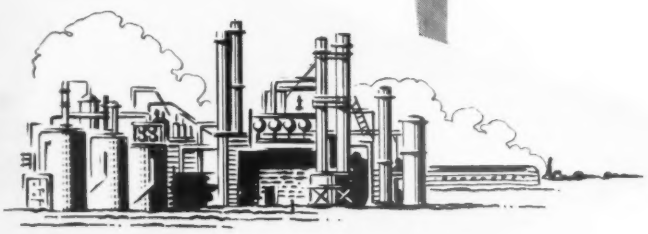

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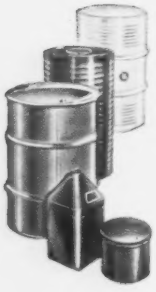

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